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Founded by J. A. Nieuwland, C.S.C.
Arthur L. Schipper, *Editor*

CONTENTS

Vol. 58 July, 1957 No. 1

EDITORIAL STAFF

ARTHUR L. SCHIPPER .... *Zoology*
Editor, University of Notre Dame, Notre Dame, Ind.

B. D. BURKS .... *Entomology*
U. S. National Museum, Washington, D. C.

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West Virginia University, Morgantown, West Virginia

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Sacramento State College, Sacramento, Calif.

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404 Livingston Ave., New Brunswick, N. J.

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University of Illinois, Urbana, Ill.

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U. S. National Museum, Washington, D. C.

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State University of Iowa, Iowa City, Iowa

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University of Notre Dame, Notre Dame, Ind.

HUGH M. RAUP .... *Plant Ecology*
Harvard Forest, Harvard University, Petersham, Mass.

LOREN P. WOODS .... *Ichthyology and Herpetology*
Chicago Natural History Museum, Chicago, Ill.

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Annotated Catalogue of the Vascular Flora of Saskatchewan

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Since the publication of *A Revised, Annotated List of the Plants of Saskatchewan* by the late W. P. Fraser and R. C. Russell in 1944, extensive changes have been made in the nomenclature and the generally accepted limitations among genera. Several species not previously known from the province have now been added to its flora. Additional localities have been included in the distribution records of less common species. Studies have indicated that published records for many species from Saskatchewan in current manuals were based upon early collections before the present boundaries of the province were established, when the whole prairie region of western Canada was known as the "Saskatchewan Plains." It is hoped, too, that the present paper of Saskatchewan plants will bring our knowledge more nearly in accordance with their actual distribution. To make this information available to the many students of Saskatchewan plants, it seems advisable to offer a modern treatment of the flora.

The following catalogue lists all the vascular plants known to occur in Saskatchewan, totaling 1380 entities. Of this number, 204 are introduced species and indicated by an asterisk(*). In this paper, species, subspecies, varieties and forms are recognized. Species of doubtful occurrence, reported from Saskatchewan in the botanical literature, are placed in the appended list of excluded species, with appropriate notations, when possible. In an endeavor to locate specimens of these "mystery plants," the Gray Herbarium, the New York Botanical Garden and other American institutions, in addition to the National Herbarium of Canada, have been of assistance, for which the writer is most grateful.

A study of plant associations, succession, ecology, the causes determining the distribution of plants and the development of the flora opens up one of the most interesting and significant fields of botanical investigation. The diversity in edaphic and climatic factors produced by the variation in topography and a wide range in latitude results in a varied flora. The majority of plants are wide-ranging and belong, largely, to either one of two phytogeographic zones: 1) the boreal coniferous forest formation, extending across the northern two-thirds, or 2) the Great Plains grassland formation covering the southern third of the area studied. However, a number of arctic and alpine species occur in the Lake Athabaska region of which a small proportion represent endemic races. In addition, a considerable proportion of the vegetation covering the Cypress Hills in the southwest corner of the area is comprised of Cordilleran species. Lodgepole pine (*Pinus contorta* var. *lati-*

folia) and Alberta spruce (*Picea glauca* var. *albertiana*) form a conspicuous feature of the vegetation in these isolated hills, indicating a continuous forest formerly extended from the Rocky Mountains eastward to the Cypress Hills, now separated by grassland plains. For a more detailed description of the plant communities present in the area, see *A Forest classification for Canada* by W. E. D. Halliday, Dept. of Mines and Resources, Bull. 89, Ottawa, 1937, and *Ecology of the Mixed Prairie in Canada* by R. T. Coupland, Ecological Monographs, 20:271-315, 1950. In *An Annotated List of the Plants of Saskatchewan* ed. 3, by the late W. P. Fraser and R. C. Russell, the distribution of each species is indicated by numbers representing the soil zones of the province where the particular species occurs.

The political boundaries of western Canada have undergone various changes in name and area, since Sieur de la Vérendrye first crossed the Great Plains and discovered the Rocky Mountains in 1743. Until 1869 the Hudson's Bay Company exercised control over the whole west (Rupert's Land) under Royal Charter. The territory was then transferred by British Parliament to the Dominion of Canada, at which time the Northwest Territories were created and Rupert's Land was included. The provisional districts of Assiniboia, Saskatchewan and Athabasca were organized in 1882. Assiniboia extended from Manitoba west to Long. 111°20'W. and from the International Boundary north to Lat. 52°N. To the north lay Saskatchewan and Athabasca. Assiniboia and Athabasca were absorbed in 1905, when the present provincial boundaries of Saskatchewan and Alberta were established.[1]

An increasing number of students have become interested in the flora making it better known through their work in different localities, and a considerable amount of literature, dealing wholly or in part with Saskatchewan plants, has been published, all of which have contributed to a greatly increased knowledge of the provincial flora.

The earliest recorded botanical collections made in the area are those by Sir John Richardson, between 1819 and 1827. He accompanied Sir John Franklin's first and second expeditions, undertaken in the years 1819-22 and 1825-27, exploring the northern interior of Canada, then known as Rupert's land, from Fort Churchill to the mouth of the Mackenzie, via Cumberland House and Methye Portage. His specimens are preserved in the herbarium of the Royal Botanic Gardens at Kew. They are cited in the classic Flora Boreali-Americana, by William J. Hooker, which was completed in 1880.

Also in Franklin's second expedition of 1825-27, was Thomas Drummond, Assistant Naturalist, who made some collections in our area at Cumberland House and Carleton House on the Saskatchewan River. Apparently most of his material came from the headwaters of the North Saskatchewan River in the Rocky Mountains, although it is impossible with the data on the sheets in American herbaria, or with the notes in Flora Boreali-Americana to classify it geographically with accuracy. He gives an account of his travels in *Sketch of a Journey to the Rocky Mountains and to the Columbia River in North America,* Hooker's Bot. Misc. 1:178-219, 1830.

The next Botanist was E. Bourgeau, who accompanied the Palliser expeditions during 1857-58-59, which explored the region from the Red River

[1] Figures supplied by the Dominion Archives, Ottawa, Canada.

to the Rocky Mountains and between the international boundary and the north branch of the Saskatchewan River. In Captain Palliser's Journals, page 247, there is a letter to Sir W. J. Hooker, written by E. Bourgeau from "Fort Garry, Saskatchewan," June 7, 1857. It is evident from the published records that all the prairie country between the Red River and the foothills of the Rockies, was at that time generally termed "Saskatchewan Plains." Palliser's diary indicates that the greater part of the collecting seasons of 1857 and 1858 were spent at Fort Garry [now Winnipeg], Fort Ellice and Turtle Mountain in what is now Manitoba, and at Pembina, North Dakota. On July 14, 1857 the Palliser expedition left Fort Garry, arriving at Fort Ellice on Aug. 17, when the height of the flowering season in that region was already past. These early collections made by Bourgeau, marked "Saskatchewan" are, no doubt, the basis of many species erroneously reported for "Saskatchewan" in current manuals, when actually they came from areas outside the present boundaries of Saskatchewan. According to accounts in the journals, Bourgeau's collections came largely from the "eastern wooded and eastern prairie districts." Plants which belong to the eastern woodland district, were collected on the canoe route from Lake Superior to Lake Winnipeg, also in the neighborhood of the Red River Settlement. On pages 254-263 of the Palliser Journals, Bourgeau gives a list of plant species, some of which are accompanied by brief notations, such as: "*Corylus americana*—Winnipeg, Saskatchewan." He defined only one species of Corylus in the region. On page 252 of his report in the Journals, he lists *C. americana* from Fort Carleton [Saskatchewan] and Fort Edmonton [Alberta]. What he had at Fort Carleton and Fort Edmonton was the more wide-ranging *C. cornuta,* whereas, *C. americana* is known to occur in the Red River valley and as far west as Souris [Manitoba] in the region traversed by Bourgeau. His collections are deposited in the herbarium of the Royal Botanic Gardens at Kew. Duplicates are in the Gray Herbarium of Harvard University. Captain John Palliser published an account of his expeditions in *Explorations in British North America,* 1857-1860, H. M. Stationary Office, London, 1863.

During the several expeditions across the Canadian prairies, between 1872 and 1906, John Macoun, pioneer Canadian botanist, made extensive plant collections in Saskatchewan. His *Catalogue of Canadian Plants* was completed in 1890.

M. O. Malte succeeded Macoun as botanist at the Victoria Memorial Museum (now the National Herbarium of Canada) in Ottawa. He made collections in Saskatchewan, chiefly grasses, during 1911 and 1917.

There are probably several hundred collections made by T. N. Willing in the Fraser Herbarium but unfortunately they are not carefully labelled and some of the essential information regarding them is lacking. It appears not all species were collected in Saskatchewan. Born in Toronto and educated there, Mr. Willing went to the North West Territories in the seventies and settled near Calgary in 1881. In 1889 he was appointed Territorial Inspector of Noxious Weeds (later called Chief Weed Inspector and Game Guardian, Sask. Dept. Agr.) and took up residence in Regina that year. In 1910 Mr. Willing became Assistant Professor of Natural History, College of Agriculture, Saskatoon, where he remained until his death in 1920.

H. M. Raup collected plants in the Lake Athabaska region, during 1926. The results of his investigations from that area are published in *Phytogeographic Studies in the Athabaska—Great Slave Lake Region,* J. Arn. Arb., 27:180-315, 1936. His collections are in the Gray Herbarium. Duplicates of nearly all species collected in that area are in the National Herbarium of Canada, Ottawa.

W. P. Fraser began collecting and studying the native plants of Saskatchewan in 1919 and continued untiringly until his death in 1943. Dr. Fraser's keen interest and enthusiasm inspired the present writer as well as other botanists in the province. Papers on Saskatchewan plants contributed by W. P. Fraser and collaborators are as follows: *List of the Flowering Plants, Ferns and Fern Allies of Saskatchewan,* W. P. Fraser and R. C. Russell, Univ. Sask., Saskatoon, 1937; *Notes on the Cyperaceae of Saskatchewan, I Scirpus,* W. P. Fraser, Can. Field-Nat. 56:104-110, 1942; *Notes on the Cyperaceae of Saskatchewan, II Carex,* G. F. Ledingham and W. P. Fraser, Amer. Midl. Nat. 29:42-50, 1943; *A Revised, Annotated List of the Flowering Plants of Saskatchewan,* late W. P. Fraser and R. C. Russell, Univ. Sask., Saskatoon, 1944; *An Annotated List of the Plants of Saskatchewan,* late W. P. Fraser and R. C. Russell, revised by R. C. Russell, G. F. Ledingham and R. T. Coupland, Univ. Sask., Saskatoon, 1954.

During 1950, J. H. Hudson collected 491 species and varieties in the vicinity of Mortlach, about 30 miles west of Moose Jaw. He records these collections, together with notes on their relative abundance and habitats, in a *Floral List of the Mortlach District, Southern Saskatchewan,* Can. Field-Nat. 65:197-210, 1951. From 1953 to 1956 (inclusive), the indefatigable and enthusiastic Mr. Hudson has added several species new to the flora of Saskatchewan.

Important collections were made by A. C. Budd, S. E. Clarke, E. W. Tisdale, J. L. Bolton, J. A. and J. B. Campbell of the Experimental Station at Swift Current. Numerous collections were made by B. J. Sallans, R. C. Russell, R. J. and F. G. Ledingham. In addition, many correspondents have contributed by sending specimens for identification. A. C. Budd's most important contribution is a key to *Plants of the Farming and Ranching Areas of the Canadian Prairies* published by the Experimental Farms Service, Department of Agriculture, Ottawa, 1952.

The writer, while residing in Saskatchewan, made extensive collections from 1934 to 1944. His *Catalogue of the Vascular Plants of Central Eastern Saskatchewan* was published in the Can. Field-Nat. 61:71-100, 1947. The greater part of six years (1946-1952) was spent in Ottawa, during which time specimens from Saskatchewan were studied at the National Herbarium and the Herbarium of the Division of Botany, Science Service, Department of Agriculture, Central Experimental Farm, Ottawa. During the summers of 1947-1949, the writer had occasion to collect Saskatchewan plants in areas not well known botanically. Results of the 1947 expedition are published in *A Botanical Survey of the Cypress Hills,* Can. Field-Nat. 68:55-92, 1954. While in Ottawa, all available botanical literature regarding plants occurring in Saskatchewan, was consulted.

In my letter files I find correspondence, some dating back twenty years, concerning my study of Saskatchewan plants. To the following named persons and to others for help in

naming plants, for advice on nomenclatural and taxonomic problems, for sending me plant specimens on loan, or searching herbaria for species reported from Saskatchewan, appreciation is hereby acknowledged: C. R. Ball, R. C. Barneby, A. A. Beetle, L. Benson, A. C. Budd, Gloria R. Campbell, L. Constance, D. S. Correll, R. T. Coupland, A. C. Cronquist, F. J. Hermann, J. H. Hudson, Eric Hultén, G. F. Ledingham, B. Maguire, H. L. Mason, F. G. Meyer, Mildred Mathias, C. V. Morton, P. A. Munz, C. L. Porter, H. M. Raup, W. H. Rickett, R. C. Rollins, R. C. Russell, H. J. Scoggan, H. K. Svenson, and T. G. Yuncker.

SUMMARY OF ABBREVIATIONS CITED

The symbols mentioned below indicate the herbaria in which the specimens cited are located. Where no symbol is appended, the specimens are in the Fraser Herbarium. No localities are cited if the species is common.

CAN—National Herbarium of Canada, National Museum of Canada, Department of Mines and Resources, Ottawa, Canada.

DAO—Division of Botany and Plant Pathology, Department of Agriculture, Central Experimental Farm, Ottawa.

DAS—Laboratory of Plant Pathology, Canada Department of Agriculture, Saskatoon, Sask.

DASC—Experimental Station, Canada Department of Agriculture, Swift Current, Sask.

GH—Gray Herbarium, Harvard University, Cambridge, Mass.

NY—Herbarium of the New York Botanical Garden, New York.

UNS—Fraser Herbarium, University of Saskatchewan, Saskatoon, Sask.

USN—United States National Museum, Washington, D.C.

The collections from Lake Athabaska, Saskatchewan, cited by Raup in his *Phytogeographic Studies in the Athabaska—Great Slave Lake Region,* J. Arn. Arb. 17:180-315, 1936, are in the National Herbarium of Canada and in the Gray Herbarium and they are indicated by the abbreviation (Raup).

Pteridophyta—Ferns and Fern Allies

OPHIOGLOSSACEAE—Adder's Tongue Family

Botrychium lunaria (L.) Sw. Moonwort.—Occasional in wooded sections of the province. Big River, McKague, Naicam, Saskatoon, Bjorkdale.

B. matricariifolium R. Br. (*B. lanceolatum* and *B. simplex* of Sask. reports, not Ångstr. or E. Hitchc.).—Camomile-leaved Grape-fern. Cypress Hills (UNS); Mortlach, Beechy (DAS). Subsp. *hesperium* Maxon & Clausen, Amisk Lake (DAO).

B. multifidum (S. G. Gmel.) Rupr. var. *intermedium* (D. C. Eat.) Farw. (*B. silaifolium* Presl.).—Leathery Grape-fern. Sandy thickets and open woods. Big River, McKague, Saskatoon (UNS); Lake Athabaska (Raup).

B. virginianum (L.) Sw. Virginia Grape-fern.—Frequent in rich woods. Cypress Hills, Big River, Bjorkdale, McKague, Emma Lake, Pike Lake, Waskesiu Lake.

POLYPODIACEAE—Fern Family

Cryptogramma crispa (L.) R. Br. ssp. *acrostichoides* (R. Br.) Hultén (var. *acrostichoides* (R. Br.) C. B. Clarke; *C. acrostichoides* R. Br.).—American Rock-fern. On granite outcrops. Clut Lake (UNS); Wekach Lake (DAS); Lake Athabaska (Raup).

C. stelleri (S. G. Gmel.) Prantl (*Pellaea gracilis* Hook.).—Slender Cliff-brake. Rock Crevices on the Precambrian Shield. Porter Lake (UNS).

Cystopteris fragilis (L.) Bernh. (*Filix fragilis* (L.) Gilib.).—Fragile Fern. Moist wooded banks. Lake Athabaska, Cypress Hills, Saskatoon, McKague.

Dryopteris austriaca (Jacq.) Woynar var. *spinulosa* (Mull.) Fiori. (*D. spinulosa* (Mull.) Watt; *Aspidium spinulosum* (Mull.) Sw.; *Thelypteris spinulosa* (Mull.) Nieuwl.).—Spinulose Shield-fern. Frequent in moist woods. Bjorkdale, Madge Lake, McKague, Peesane, Waskesiu Lake.

D. cristata (L.) A. Gray (*Thelypteris cristatum* (L.) Nieuwl.).— Crested Shield-fern. Occasional in wet woods. Crooked River, Bjorkdale, Tisdale, White Fox, Meadow Lake.

D. fragrans (L.) Schott (*Thelypteris fragrans* (L.) Nieuwl.).—Fragrant Shield-fern. On outcrops of the Precambrian Shield. Clut Lake (UNS); Lake Athabaska (Raup).

Gymnocarpium dryopteris (L.) Newm. (*Dryopteris disjuncta* (Ledeb.) Morton; *D. linnaeana* C. Chr.; *Phegopteris dryopteris* (L.) Fée; *Thelypteris dryopteris* (L.) Slosson). —Oak-fern. Occasional in wet woods. Crooked River, Speddington, Waskesiu Lake, Sulphide Lake, Lake Athabaska, Lac la Ronge.

G. robertianum (Hoffm.) Newm. (*Dryopteris robertiana* (Hoffm.) C. Chr.; *Phegopteris robertiana* (Hoffm.) A. Br.; *Thelypteris robertiana* (Hoffm.) Slosson).—Scented Oak-fern. Granite cliffs. Lake Athabaska (UNS).

Matteuccia struthiopteris (L.) Todaro var. *pensylvanica* (Willd.) Morton (*Pteretis pensylvanica* (Willd.) Fern.; *P. nodulosa* (Michx.) Nieuwl.; *Onoclea struthiopteris* (L.) Fern.).—Ostrich Fern. Damp woods. Madge Lake, McKague, Qu'Appelle, Sutherland, Tisdale, Waskesiu Lake, Crooked River. This is the largest of our ferns with fronds up to 2 meters long.

Pellaea glabella Mett. ex Kuhn (*P. occidentalis* (E. Nels.) Rydb.; *P. pumila* Rydb.). —Smooth Cliff-brake. Precambrian outcrops northward. Lake Athabaska (Raup); Meridian Creek near Flin Flon (DAS).

Polypodium vulgare L. var. *virginianum* (L.) Eaton (*P. virginianum* L.).—Common Polypody. Athabaska Lake, Clut Lake (UNS).

Thelypteris phegopteris (L.) Slosson (*Dryopteris phegopteris* (L.) Chr.; *Phegopteris polypodioides* (L.) Fée.—Beech Fern. Wooded banks in the Precambrian Shield. Clut Lake, Porter Lake (UNS); Lake Athabaska (Raup).

Woodsia glabella R. Br.—Smooth Woodsia. Rock crevices. Lake Athabaska (Raup); Meridian Creek SW of Flin Flon (DAS).

W. ilvensis (L.) R. Br.—Rusty Woodsia. Common in rock crevices at Lake Athabaska (Raup).

W. oregana D. C. Eat.—Oregon Woodsia. Rare on basic rocks. Denare Beach (DAS); Cypress Hills (DAS, USN); Lake Athabaska (Raup).

W. scopulina D. C. Eat.—Mountain Woodsia. North shore of Lake Athabaska (Raup).

MARSILEACEAE—Marsilea Family

Marsilea mucronata A. Br. (*M. vestita* of auth., not Hook. & Grev.).—Hairy Pepperwort. Slough bottoms. Glen Kerr, Juniata, Trossachs, Wiseton, Yeomans.

EQUISETACEAE—Horsetail Family

Equisetum arvense L.—Common Horsetail. Common in woods, shores and fields. This species varies with environment; several ecotypes have been described as species, varieties and formae.

E. hiemale L. ssp. *affine* (Engelm.) Stone (var. *affine* (Engelm.) A. A. Eat.; var. *pseudohiemale* (Farw.) Morton; *E. prealtum* Raf.).—Common Scouring Rush. Frequent on sandy banks and moist slopes.

E. fluviatile L. (*E. limosum* L.).—Swamp Horsetail. Common in marshes and along shores.

E. laevigatum A. Br. (*E. intermedium* (A. A. Eat.) Rydb.; *E. kansanum* Schaffn.). —Loose-sheathed Scouring Rush. Frequent on clay banks and sandy soil.

E. palustre L.—Marsh Horsetail. Occasional along shores. Nipawin, Hudson Bay Junction; Lake Athabaska (Raup).

E. pratense Ehrh.—Meadow Horsetail. Frequent in woods. McKague, Meadow Lake, Nipawin, QuAppelle, Cypress Hills.

E. scirpoides Michx.—Dwarf Scouring Rush. Frequent in coniferous woods. Cypress Hills, McKague, Meadow Lake; Lake Athabaska (Raup).

E. sylvaticum L. var. *pauciramosum* Milde.—Woodland Horsetail. Common in moist woods. Cypress Hills, Waskesiu Lake, Bjorkdale, McKague (UNS); Lake Athabaska (Raup).

E. variegatum Schleich.—Variegated Horsetail. Gravelly shores and bogs. McKague, Cypress Hills, Nipawin (UNS, DAO); Lake Athabaska (Raup).

ISOETACEAE—Quillwort Family

Isoëtes muricata Dur. (*I. braunii* Dur., not Unger).—Quillwort. In shallow water at Creighton near Flin Flon (DAS).

LYCOPODIACEAE—Club-moss Family

Lycopodium annotinum L. (incl. var. *pungens* Desv. and var. *acrifolium* Fern.).—Stiff Club-moss. Coniferous woods. Pre Ste. Marie, Waskesiu Lake, White Fox, Heart Lakes, Crooked River, Cypress Hills; Lake Athabaska (Raup).

L. clavatum L.—Running Club-moss. Coniferous woods northward. Meadow Lake, Candle Lake; Lake Athabaska (Raup).

L. complanatum L.—Ground Cedar. Common in pine woods northward. Pre Ste. Marie (UNS, DAO); Lake Athabaska (Raup).

L. obscurum L. (*L. dendroideum* Michx.).—Ground Pine. Sandy woods. McKague, Prince Albert, Waskesiu Lake, Cypress Hills, Kinestino; Lake Athabaska (Raup).

L. sabinaefolium Willd. var. *sitchense* (Rupr.) Fern. (*L. sitchense* Rupr.).—Sitka Ground Cedar. Sandy woods. Lake Athabaska (Raup).

L. selago L. Mountain Club-moss. Rock crevices. Lake Athabaska (Raup).

L. tristachyum Pursh.—Three-spiked Ground Cedar. Sandy thickets and open woods. Lake Athabaska (Raup).

SELAGINELLACEAE—Little Club-moss Family

Selaginella densa Rydb.—Prairie Selaginella. Common on dry prairie.

S. rupestris (L.) Spring.—Rock Selaginella. Sandy pine woods and granite outcrops northward. Hudson Bay Junction, Nipawin, Prince Albert, Meadow Lake, Ile a la Crosse; Lake Athabaska (Raup).

S. selaginoides (L.) Link.—Prickly Selaginella. Found in bogs northward. Pike Lake, Prince Albert, Nipawin (UNS, DAO).

Spermatophyta—Seed Plants
GYMNOSPERMAE—Gymnosperms
PINEACEAE—Pine Family

Abies balsamea (L.) Mill.—Balsam Fir. Occasional in mixed woods northward. Big River, Emma Lake, Nipawin, Prairie River, Candle Lake, Waskesiu Lake.

Juniperus communis L. var. *saxatilis* Pall. (var *montana* Ait.; *J. sibirica* Burgsd.).—Low Juniper. Occasional on exposed hills and river banks. Cypress Hills, Great Sand Hills, Chaplin, Nipawin, Langham; Lake Athabaska (Raup).

J. horizontalis Moench (*Sabina horizontalis* (Moench) Rydb.).—Creeping Juniper. Common on dry river banks and sandy knolls.

Larix laricina (Du Roi) K. Koch.—Tamarack. Common in swampy ground northward, usually associated with black spruce (*Picea mariana*).

Picea glauca (Moench) Voss (*P. canadensis* (Mill.) B.S.P., not Link).—White Spruce. Abundant in the mixed wood section northward. Our largest forest tree, reaching a height of 120 feet and a diameter of 4 feet.

P. glauca var. *albertiana* (S. Brown) Sarg. (*P. albertiana* S. Brown; *P. glauca* var. *porsildiorum* Raup).—Alberta White Spruce. Common in the Cypress Hills where it is the only spruce found.

P. mariana (Mill.) B.S.P.—Black Spruce. Common in low swampy ground, comprising the dominant forest cover in the northern coniferous section.

Pinus banksiana Lamb.—Jack Pine. Abundant in sandy soil northward, sometimes associated with other tree species.

P. contorta Dougl. ex Loud. var. *latifolia* Engelm. ex S. Wats. (*P. murrayana* Grev. & Balf.; *P. contorta* var. *murrayana* (Grev. & Balf.) Engelm.—Lodgepole Pine. Forming the dominant forest cover in the Cypress Hills, not found elsewhere in the area.

Angiospermae—Angiosperms
MONOCOTYLEDONEAE—Monocotyledons
TYPHACEAE—Cat-tail Family

Typha latifolia L.—Cat-tail. Common in marshes and shores of lakes and streams.

SPARGANIACEAE—Burr-reed Family

Sparganium angustifolium Michx.—Narrow-leaved Burr-reed. Ponds and slow streams at Lake Athabaska (Raup).

S. eurycarpum Engelm.—Giant Burr-reed. Common along shores of lakes and rivers. Pike Lake, Midale, McKague.

S. fluctuans (Morong) B. L. Robins.—Floating Burr-reed. Quiet ponds. Meridian Creek at bridge 5 miles SW of Flin Flon (DAS); Lake Athabaska (Raup).

S. minimum Fries.—Small Burr-reed. Pond margins. McKague (UNS, DAO); Birch Lake (DAS); Lake Athabaska (Raup).

S. multipendunculatum (Morong) Rydb. (*S. acaule* of Fraser and Russell, not Rydb.).—Many-stalked Burr-reed. Common along margins of lakes, sloughs and slow streams.

NAJADACEAE (Zannichelliaceae)—Pondweed Family

Potamogeton alpinus Balbis ssp. *tenuifolium* (Raf.) Hultén (var. *tenuifolius* (Raf.) Ogden; *P. subellipticus* Fern.).—Northern Pondweed. Prince Albert, Lac la Ronge (UNS, DAS); Lake Athabaska (Raup).

P. amplifolius Tuckerm.—Large-leaved Pondweed. Waskesiu Lake (UNS, DAO).

P. filiformis Pers. var. *borealis* (Raf.) St. John.— Filiform Pondweed. Frequent in lakes northward. Emma Lake, Meeting Lake, Redberry Lake, Waskesiu Lake.

P. filiformis var. *macounii* Morong (*P. interior* Rydb.).—In small stream at Ravenscrag (DAS).

P. foliosus Raf.—Leafy Pondweed. Spur Creek, Crane Lake (CAN).

P. friesii Rupr.—Fries' Pondweed. Methye Portage (CAN); Waskesiu Lake (UNS); McKague (CAN, DAO, UNS).

P. gramineus L. var. *graminifolius* Fries (*P. heterophyllus* Schreb.).—Grassy-leaved Pondweed. Axis Lake near Lake Athabaska, Yorkton, Saskatoon, Battleford (UNS); Lake Athabaska (Raup).

P. natans L.—Common Floating Pondweed. Occasional in ponds. Prince Albert National Park, McKague (UNS, DAO).

P. obtusifolius Mert. & Koch.—Blunt-leaved Pondweed. In small ponds. Lake Athabaska (Raup).

P. pectinatus L.—Fennel-leaved Pondweed. Common in lakes and sloughs. Jack Fish Lake, Wallwort (UNS, DAO); Lake Athabaska (Raup).

P. perfoliatus L. ssp. *richardsonii* (Benn.) Hultén (var. *richardsonii* Benn.; *P. richardsonii* (Benn.) Rydb.).—Richardson's Pondweed. Common in ponds, lakes and streams.

P. praelongus Wulf.—White-stemmed Pondweed. Shallow Lakes. Pike Lake (UNS); Lake Athabaska (Raup).

P. pusillus L. var. *mucronatus* (Fieber) Graebn. (*P. panormitanus* Biv.; *P. berchtoldii* Fieber).—Small Pondweed. In ponds and streams. Spur Creek, Fort Carleton (CAN).

P. strictifolius Benn.—Narrow-leaved Pondweed. In ponds and lakes. Pike Lake, Prince Albert National Park (UNS).

P. vaginatus Turcz.—Sheathed Pondweed. Common in lakes and ponds.

P. zosteriformis Fern. (*P. zosterifolius* of Amer. auth., not Schum.; *P. compressus* of Amer. auth., not L.).—Zostera-like Pondweed. Pike Lake, Waskesiu Lake (UNS).

Ruppia maritima L.—Ditch Grass. In saline lakes. Johnstone Lake (CAN); Lestock (UNS).

R. maritima var. *occidentalis* (S. Wats.) Graebn. (*R. occidentalis* S. Wats.).—Western Ditch Grass. Common in lakes and ponds.

Zannichellia palustris L.—Horned Pondweed. Occasional in brackish ponds of the prairie region. South Saskatchewan River near Elbow (CAN); Cadillac, Great Deer, Swift Current (UNS).

SCHEUCHZERIACEAE (Juncaginaceae)—Arrow-grass Family

Triglochin maritima L.—Seaside Arrow-grass. Common in alkaline marshes and bogs.

T. palustris L.—Marsh Arrow-grass. Occasional in bogs. McKague, Cypress Hills (UNS, DAO).

Scheuchzeria palustris L. var. *americana* Fern.—Scheuchzeria. Rare in bogs. Prince Albert National Park (UNS); Lake Athabaska (Raup).

ALISMACEAE (Alismataceae)—Water-plantain Family

Alisma gramineum K. C. Gmel. (*A. geyeri* Torr.).—Geyer's Water Plantain. Frequent around sloughs in the prairie region. Battleford, Fife Lake, Quill Lake, Swift Current.

A. plantago-aquatica L. var. *brevipes* (Greene) Farwell (*A. brevipes* Greene; *A. triviale* Pursh).—Western Water-plaintain. Common in marshes.

A. plantago-aquatica var. *parviflora* (Pursh) Farwell (*A. parviflora* Pursh; *A. subcordatum* Raf.).—Small-flowered Water-plantain. Marshy shores; scarce. Corinne, Glidden, Pike Lake (UNS). See: Farwell in Rep. Comm. Parks & Boulev. Detroit 9:44, 1900.

Sagittaria cuneata Sheld.—Arum-leaved Arrow-head. Common along margins of ponds and lakes or in sluggish streams where the leaves become ribbon-like.

S. latifolia Willd.—Broad-leaved Arrow-head. Lake shores. Pike Lake, Hudson Bay Junction (UNS, DAO).

ELODEACEAE (Hydrocharitaceae)—Water-weed Family

Elodea canadensis Michx. (*Anacharis canadensis* (Michx.) Planch.; *Philotria canadensis* (Michx.) Britt.; *Elodea planchonii* Casp.).—Water-weed. Carnduff (UNS); Souris River in Saskatchewan (CAN).

GRAMINEAE (Poaceae)—Grass Family

Agropyron albicans Scribn. & Smith.—Awned Northern Wheat-grass. Frequent on dry prairie. Beaver Flats, Humboldt, Sutherland, Swift Current, Cypress Hills.

A. albicans var. *griffithsii* (Scribn. & Smith ex Piper) Beetle (*A. griffithsii* Scribn. & Smith; *A. bakeri* of Fraser and Russell, not E. Nels.).—Griffith's Wheat-grass. Open prairie. Saskatoon (UNS); Hodgeville (UNS, DAS, as *A. bakeri*).

**A. cristatum* (L.) Gaertn.—Crested Wheat-grass. Cultivated and escaped in many places in the prairie region.

A. dasystachyum (Hook.) Scribn. (*A. subvillosum* (Hook.) A. Nels.; *Elymus hirtiflorus* of Sask. reports, not Hitchc.).—Northern Wheat-grass. Common on dry prairie.

**A. desertorum* (Fisch.) Schult.—Mountain Crested Wheat-grass. Escaped from cultivation. *A. cristatum* and *A. desertorum* are well adapted to the dry plains region and some plantings probably represent a mixture of both species. Some conservative taxonomists continue to combine *A. desertorum* with *A. cristatum*.

**A. elongatum* (Host) Beauv.—Tall Wheat-grass. Cultivated successfully on wet alkaline meadows in the prairie region.

**A. intermedium* (Host) Beauv.—Intermediate Wheat-grass. Planted to revegetate range land in the prarie region.

**A. repens* (L.) Beauv).—Couch-grass. Common as a troublesome weed in cultivated ground. Length of awns variable.

A. riparium Scribn. & Smith.—Streambank Wheat-grass. Scarce on prairie. Scott (UNS); Cypress Hills (CAN, DAO, as *A. inerme*).

A. smithii Rydb.—Western Couch-grass. Common on dry prairie.

A. smithii var. *molle* (Scribn. & Smith) M. E. Jones (*A. molle* Scribn. & Smith).—Sandy prairie. McKague (DAO).

A. spicatum (Pursh) Scribn. & Smith.—Bluebunch Wheat-grass. Frequent on prairie. Scott, Sutherland, Swift Current, Vidora, Cypress Hills (UNS, DAO).

A. trachycaulum (Link) Malte (var. *majus* (Vasey) Fern.; var. *novae-angliae* (Scribn.) Fern.; *A. pauciflorum* (Schwein.) Hitchc.; *A. tenerum* Vasey).—Western Wheat-grass. Common in native grassland and extensively cultivated.

A. trachycaulum var. *unilaterale* (Cassidy & O'brien) Malte (var. *glaucum* (Pease & Moore) Malte; *A. subsecundum* (Link) Hitchc.; *A. richardsonii* (Trin.) Schrad.).—Awned Wheat-grass. Common on prairie and around woods. *Agropyron trachycaulum* is widely distributed and adapted to a wide range of environment resulting in various morphological variations of which var. *unilaterale* is most distinctive. For additional synonyms see: Hitchc. Man. ed. 2, 800-2, 1951. A specimen from Pre Ste. Marie, August J. Breitung 1298 (DAO), tentatively referred to *Elymus innovatus* in Can. Field Nat. 61:77, 1947, is considered to be a hybrid between *Agropyron trachycaulum* var. *unilaterale* and *Elymus innovatus* by E. Lepage in Naturaliste Canadien 79:256, 1952.

**A. triticeum* Gaertn.—Annual Wheat-grass. Cypress Hills, Maple Creek (UNS).

Agrostis alba L. (*A. stolonifera* L.)—Redtop. Common in damp thickets; widely distributed.

A. alba var. *palustris* (Huds.) Pers. (*A. palustris* Huds.).—Creeping Bent. Occasional along margins of streams. Hudson Bay Junction, Maple Creek, Swift Current, Tisdale, Cypress Hills.

A. borealis Hartm.—Northern Bent-grass. Damp rocky and sandy shore of Lake Athabaska (Raup).

A. exarata Trin.—Spike Redtop. Moist woods. Cypress Hills (UNS, DAO); Pike Lake, Swift Current (UNS); Mortlach (DAO).

A. scabra Willd. (*A. hiemalis* of western authors, not BSP.).—Rough Hair-grass. Frequent in wet meadows.

Alopecurus aequalis Sobol.—Short-awned Foxtail. Common in wet meadows and shallow water. *A. geniculatus* L. is reported from the area in Hitchc. Man. ed. 2, but no specimens seen by the writer.

A. glaucus Less. (*A. occidentalis* Scribn. & Tweedy. *A. alpinus* of Hitchc. Man., not J. E. Smith).—Western Foxtail. A Rocky Mountain species found rare in the Cypress Hills (DAO, CAN). Perhaps best regarded as a subspecies of *A. alpinus.*

Andropogon gerardi Vitman (*A. furcatus* Muhl.; *A. provincialis* Lam., not Retz.).—Big Blue-stem. In southeastern part of the area. Carlyle, St. Hubert, Wapella, Yorkton.

A. scoparius Michx. (*Schizachyrium scoparium* (Michx.) Nash).—Little Blue-stem. Frequent in open shallow bogs on sandy prairie.

Aristida longiseta Steud. var. *robusta* Merr.—Red Three-awn. Along the southern border of the area. Val Marie (UNS, DASC).

**Avena fatua* L. Wild Oats. Noxious weed in cultivated fields and roadsides.

**A. sativa* L. Oats. Cultivated extensively and spontaneous along roadsides; not persistent but repeatedly reestablished.

Beckmannia erucaeformis (L.) Host ssp. **syzigachne** (Steud.) Breitung, comb. nov. (*Panicum syzigachne* Steud., Flora 29:19, 1846; *B. erucaeformis* var. *uniflora* Scribn.; *B. syzigachne* (Steud.) Fern.).—Slough-grass. Common in wet meadows and pond margins in wooded areas.

Bouteloua curtipendula (Michx.) Torr.—Tall Gramma. On prairie in southeast corner of the area. Oxbow, Hitchcock (UNS).

B. gracilis (HBK.) Lag ex Steud.—Blue Gramma. Common on prairie and plain.

Bromus anomalus Rupr. ex Fourn. (*B. porteri* (Coult.) Nash; *B. kalmii* of report from Sask. by Macoun, Cat. Can. Plants, not A. Gray).—Nodding Brome. Common in borders of woods and moist prairie.

B. carinatus Hook. & Arn. var. *marginatus* (Nees.) Hitchc. (*B. breviaristatus* Buckl.).—California Brome. Open woods in SW Sask. Cypress Hills, Maple Creek, Wood Mtn.

B. ciliatus L. (*B. dudleyi* Fern.).—Fringed Brome. Common around bluffs.

**B. inermis* Leyss.—Awnless Brome. Cultivated extensively and escaped in many places.

**B. japonicus* Thunb.—Japanese Chess. Growing as a weed in some areas.

B. latiglumis (Shear) Hitchc.—Broad-glumed Brome. Common on shaded stream banks.

B. pumpellianus Scribn.—Northern Brome. Common in wooded areas. McKague (UNS, DAO); Lake Athabaska (Raup).

B. purgans L.—Canada Brome. Frequent in aspen woods. Pike Lake, Cypress Hills.

**B. racemosus* L.—Smooth Brome. Regina (UNS). Not established.

**B. tectorum* L.—Downey Chess. Along roadsides and in waste places. Piapot, Prince Albert, Swift Current.

Calamagrostis canadensis (Michx.) Beauv.—Bluejoint. Common in woods; widely distributed. A highly variable species; distinct varieties can not be precisely differentiated. In the prairie region occurs the smaller extreme, var. *macouniana* (Vasey) Stebbins, with narrower, more densely flowered panicle and smaller spikelets.

C. canadensis var. *robusta* Vasey.—Common in the Lake Athabaska region (Raup), and perhaps elsewhere in our area.

C. canadensis var. *scabra* (Presl.) Hitchc. (*C. scabra* Presl.).—Arctic Bluejoint. Black Lake and Black River east of Lake Athabaska (CAN). Probably occurs across the

extreme northern part of the area. Hultén, Fl. Alaska & Yukon, Pt. 2:162, 1941, maintains ssp. *langsdorfii* (Link) Hultén is circumboreal, stating: ". . . the cultivated type-specimens represent an unusual form of the plant, but I cannot find that this is sufficient reason for rejecting the name. When a species is described from a cultivated specimen such differences will often occur. In any case no Old World species exactly corresponding to the cultivated type-specimen occurs."

C. inexpansa A. Gray. (*C. brevior* Vasey; *C. americana* Scribn.; *C. elongata* (Kearney) Rydb.—Northern Reed-grass. Common in wet meadows; widely distributed.

C. montanensis Scribn.—Plains Reed-grass. Common on dry sandy prairie.

C. neglecta (Ehrh.) Gaertn., Mey. & Scherb. (*C. micrantha* Kearney).—Narrow Reed-grass. Frequent along margins of lakes and streams. Cypress Hills, McKague, Swift Current; Lake Athabaska (Raup).

C. purpurascens R. Br.—Purple Reed-grass. Frequent in rock crevices, sandy ridges and beaches of Lake Athabaska (Raup).

C. rubescens Buckl.—Pine Grass. Frequent in dry coniferous woods. Cypress Hills, Maple Creek (DASC, DAO). See: Can. Field-Nat. 62:173, 1948.

Calamovilfa longifolia (Hook.) Scribn.—Sand-grass. Common on very sandy soil in the prairie region.

Catabrosa aquatica (L.) Beauv.—Brook Grass. Frequent in springy places. Cypress Hills (DAO).

Cinna latifolia (Trev.) Griseb.—Slender Wood-grass. Frequent in damp woods. McKague, Cypress Hills.

**Dactylis glomerata* L.—Orchard Grass. Waskesiu Lake (UNS).

Danthonia californica Boland. var. *americana* (Scribn.) Hitchc.—California Oat-grass. Frequent in grassland in southwestern part of the area. Cypress Hills, Dinsmore, Mortlach (UNS, DAO).

D. intermedia Vasey.—Wild Oat-grass. Frequent on prairie. McKague, Saskatoon, Cypress Hills; Lake Athabaska (Raup).

D. spicata (L.) Beauv. ex Roem. & Schult. (*D. thermalis* Scribn.; *D. pinetorum* Piper).—Poverty Oat-grass. Frequent in pine woods. Cypress Hills (UNS, DAO); Beauval, Meadow Lake (DAO); Lake Athabaska (Raup).

D. unispicata (Thurb.) Munro ex Macoun.—One-spiked Oat-grass. Depressions on prairie in southwestern part of the area. Cypress Hills, Swift Current (DAO, DASC); Dinsmore (DAO).

Deschampsia caespitosa (L.) Beauv.—Tufted Hair-grass. Common in moist meadows and shores.

D. mackenzieana Raup (*Elymus mackenzieana* of Fraser and Russell).—Mackenzie Hair-grass. Common on sandy beaches and dunes of Lake Athabaska (Raup). Perhaps only a geographical race of the variable Alaskan and Siberian *D. bottnica* (Wahl.) Trin.

**Digitaria sanguinalis* (L.) Scop. (*Syntherisma sanguinale* (L.) Dulac).—Large Crab-grass. Frequent in gardens and waste places.

Distichlis spicata (L.) Greene var. *stricta* (Torr.) Beetle (*D. stricta* (Torr.) Rydb.).—Alkali Grass. Common in alkaline meadows in the prairie region.

**Echinochloa crusgalli* (L.) Beauv.—Barnyard Grass. Occasional in gardens and waste places.

Elymus arenarius L. ssp. *mollis* (Trin.) Hultén (*E. mollis* Trin., *E. arenarius* var. *villosus* E. Meyer).—Sea Lyme-grass. Common on sandy beaches and dunes along the shore of Lake Athabaska (Raup).

E. canadensis L. (*E. philadelphicus* L.; *E. robustus* Scribn. & Smith; *E. interruptus* of Fraser and Russell, not Buckl.).—Nodding Wild Rye. Common on sandy soil, river banks and lake shores; widely distributed.

E. cinereus Scribn. & Merr. (*E. condensatus* of Sask. reports, not Presl).—Giant Wild Rye. Scarce on open hillsides in the prairie region. Cypress Hills (DAO); Vanguard, Indian Head (UNS). The similar *E. condensatus* is found along the coast of California.

E. glaucus Buckl.—Smooth Wild Rye. Mixed woods in the Cypress Hills (UNS, DAO).

E. innovatus Beal.—Hairy Wild Rye. Common in wooded areas northward and in the Cypress Hills.

**E. junceus* Fisch.—Russian Wild Rye. A valuable forage grass adapted to the drier conditions found on the prairies and plains of southern Saskatchewan.

E. macounii Vasey.—Macoun's Wild Rye. Frequent on prairie. Considered by some botanists to be a hybrid between *Agropyron trachycaulum* and *Hordeum jubatum.*

E. virginicus L.—Virginia Wild Rye. Frequent on shaded banks; widely distributed.

E. virginicus var. *submuticus* Hook. (*E. curvatus* Piper).—Short-awned Virginia Wild Rye. On moist shaded river banks. Pike Lake, Saskatoon, Tisdale (UNS).

Festuca altaica Trin. var. **scabrella** (Torr.) Breitung, stat. nov. (*F. scabrella* Torr. in Hook. Fl. Bor. Amer. 2:252, 1840).—Rough Fescue. Widespread and frequent in moist prairie; abundant in the Cypress Hills.

F. idahoensis Elmer.—Bluebunch Fescue. Common on the Cypress Hills plateau.

F. octoflora Walt. (*Vulpia octoflora* (Walt.) Rydb.).—Six-weeks Fescue. Open ground. Piapot (UNS).

F. ovina L. var. *brachyphylla* (Schultes) Piper (*F. brachyphylla* Schultes).—Alpine Fescue. Rocky shores around Lake Athabaska (Raup).

F. ovina var. *saximontana* (Rydb.) Gleason (ssp. *saximontana* (Rydb.) St.-Yves; *F. saximontana* Rydb.).—Rocky Mountain Fescue. Frequent on dry prairie and exposed hillsides.

F. rubra L. (*F. arenaria* Osbeck).—Red Fescue. Sand dunes and beaches of Lake Athabaska (Raup).

Glyceria borealis (Nash) Batch. (*Panicularia borealis* Nash.).—Northern Manna-grass. Frequent in shallow sloughs and marshes.

G. maxima (Hartm.) Holmb. ssp. *grandis* (S. Wats.) Hultén (*G. grandis* S. Wats.; *P. grandis* (S. Wats.) Nash).—Tall Manna-grass. Common in marshes and along shores; widely distributed.

G. pulchella (Nash) K. Sch. (*G. pauciflora* of Fraser and Russell, not Presl.).—Graceful Manna-grass. Occasional in wet woodlands northward. Waskesiu Lake (UNS); Meadow Lake, McKague (DAO); Lake Athabaska (Raup).

G. striata (Lam.) Hitchc. var. *stricta* (Scribn.) Fern. (*P. nervata* (Willd.) Kuntze).—Fowl Manna-grass. Frequent along borders of lakes and ponds. McKague, Pike Lake, Saskatoon, Cypress Hills, Swift Current (UNS, DAO); Lake Athabaska (Raup).

Helictotrichon hookeri (Scribn.) Henr. (*Avena hookeri* Scribn.).—Hooker's Oat-grass. Common on dry prairie.

Hierochloë odorata (L.) Wahl. (*Torresia odorata* (L.) Hitchc.).—Sweet Grass. Common in meadows. A troublesome weed in sand in some districts. Lake Athabaska (Raup).

Hordeum brachyantherum Nevski (*H. nodosum* Amer. auth., not L.).—Meadow Barley. Moist depressions on prairie in the Cypress Hills (DAO, DASC).

H. jubatum L.—Wild Barley. Common in meadows. Lake Athabaska (Raup).

H. jubatum var. *caespitosum* (Scribn.) Hitchc. (*H. caespitosum* Scribn.).—Short-awned Wild Barley. Frequent in moist meadows in the western part of the area. Saskatoon, Saskatchewan Landing, Scout Lake, Sutherland.

**H. vulgare* L.—Barley. Cultivated and often spontaneous along roadsides. Bearded and hooded varieties are grown.

Koeleria cristata (L.) Pers. (*K. gracilis* Pers.; *K. latifrons* (Domin) Rydb.).—June-grass. Common on prairie.

**Lolium multiflorum* Lam.—Italian Rye-grass. Tisdale, Breitung 342 (DAO).

**L. perenne* L.—Perennial Rye-grass. Indian Head, Dore & Boivin 13058 (DAO).

**L. persicum* Boiss. & Hohen. (*L. rigidum* of Amer. auth., not Gaud.; *L. temulentum* var. *leptochaeton* of Fraser and Russell, not A. Br.).—Persian Darnel. Frequent and widespread in cultivated fields. See: Dore in Scientific Agriculture 30:157-164, 1950.

Muhlenbergia asperifolia (Nees & Meyen) Parodi (*Sporobolus asperifolius* Nees & Meyen). Scratch Grass. Moist depressions on prairie. Antelope, Swift Current, Yorkton, Saskatoon.

M. cuspidata (Torr.) Rydb.—Prairie Muhly. Frequent on dry exposed hills and prairie.

M. racemosa (Michx.) BSP. (*M. glomerata* Torr.).—Marsh Muhly. Frequent in moist meadows and on river banks. McKague, Cypress Hills.

M. richardsonis (Trin.) Rydb. (*M. squarrosa* (Trin.) Rydb.).—Mat Muhly. Common in moist meadows and low prairie.

Munroa squarrosa (Nutt.) Torr.—False Buffalo Grass. Brunyee's Ranch near Verlo, about 50°22′ N., 108°39′ W. (DAO, DASC). See: Can. Field-Nat. 62:173, 1948.

Oryzopsis asperifolia Michx.—White-grained Mountain Rice. Common in woods; widely distributed.

O. canadensis (Poir.) Torr. (*Stipa canadensis* Poir.).—Canadian Rice-grass. Edge of aspen groves. Cochin, McKague (UNS, DAO).

O. hymenoides (Roem. & Schult.) Ricker (*Eriocoma hymenoides* (Roem. & Schult.) Rydb.).—Indian Rice-grass. Frequent in sandy soil on prairie.

O. micrantha (Trin. & Rupr.) Thurb.—Little-seeded Rice-grass. Dry banks on prairie. Saskatcon, Bestville, Saskatchewan Landing (UNS); Mortlach (DAS).

O. pungens (Torr.) Hitchc.—Slender Mountain Rice. Coniferous woods northward. Macdowall, McKague, Prince Albert, Waskesiu Lake; Lake Athabaska (Raup).

Panicum capillare L. var. *occidentale* Rydb. (*P. barbipulvinatum* Nash).—Witch-grass. A weed occasional in cultivated fields and gardens. Elfros, Indian Head (UNS).

P. depauperatum Muhl.—Starved Panic-grass. Southeastern corner of the area. Moosomin (UNS).

P. subvillosum Ashe.—Hairy Panic-grass. Sandy and rocky pine woods in the Pre-cambrian Shield. Creighton and Amisk Lake near Fin Flon (DAS, DAO); Lake Athabaska (Raup). Spiklets 1.6-1.9 mm long.

P. wilcoxianum Vasey.—Witch Grass. Sand dunes in pine barrens. Welby, Prince Albert (DAO). Spiklets 2.5-2.9 mm long.

P. virgatum L.—Switch-grass. Moist meadows in SE corner near Gainsborough (UNS).

P. xanthophysum A. Gray.—Yellow-green Panic-grass. On Precambrian outcrops. Denare beach and Creighton (DAS, DAO).

Phalaris arundinacea L.—Reed Canary-grass. Common in wet places through the wooded sections. *Var. *picta* L. (Ribbon Grass) is cultivated for ornament.

**P. canariensis* L.—Canary Grass. Introduced annual in waste places. Rosetown, Saskatoon (UNS).

Phleum alpinum L.—Mountain Timothy. Frequent in meadows on the Cypress Hills plateau (UNS, DAO, DASC).

**P. pratense* L.—Timothy. Cultivated and escaped in many places.

Phragmites communis Trin.—Reed Grass. Common in marshes and along lakes and rivers northward. This is the largest of our native grasses, attaining a height of from 6 to 10 feet. Our plant is sometimes segregated as var. *berlandieri* (Fourn.) Fern., but most botanists do not recognize the variety.

Poa alpina L.—Alpine Blue-grass. Rocky outcrops around Lake Athabaska (Raup).

P. ampla Merr.—Big Blue-grass. Moist meadows and rocky slopes. Gull Lake (UNS); Cypress Hills (CAN, as *P. nevadensis*).

**P. annua* L.—Annual Blue-grass. Weed in gardens and woodland trails. McKague, Montreal Lake, Cypress Hills (UNS, DAO); Mortlach (DAO).

P. arida Vasey (*P. pratensiformis*, *P. overi* Rydb.).—Plains Blue-grass. Common on dry prairie.

P. canbyi (Scribn.) Piper (*P. lucida* Vasey).—Canby's Blue-grass. Frequent on open plains.

**P. compressa* L.—Flat-stemmed Meadow-grass. Frequent along roadsides; escaped from cultivation. In North America, erroneously called "Canada Blue-grass." Introduced from Europe—not from Canada.

P. cusickii Vasey (*P. subaristata* Scribn.).—Early Blue-grass. Common on dry hills and plains in southwestern part of our area.

P. glauca Vahl.—Glaucous Blue-grass. On rocky hills and sandy shores of Lake Athabaska (Raup); Lac la Ronge, Amisk Lake (DAS).

P. glaucifolia Scribn. & Will.—Glaucous-leaved Blue-grass. Occasional in aspen bluffs. Cypress Hills (DAO); Swift Current (UNS, DASC).

P. interior Rydb. (*P. nemoralis* L. var. *interior* (Rydb.) Butters & Abbe; *P. rupicola* of Fraser and Russell, not Nash).—Inland Blue-grass. Common on prairie and in meadows.

P. juncifolia Scribn.—Alkali Blue-grass. Saline soil on prairie. Mansfield, Cypress Hills (UNS, DAO).

P. lanata Scribn. & Merr.—Lanate Blue-grass. Occasional on partially stabilized sand dunes of Lake Athabaska (Raup).

P. nervosa (Hook.) Vasey (*P. wheeleri* Vasey).—Wheeler's Blue-grass. Dry slopes. Cypress Hills, Donavon (UNS, DAO).

P. palustris L. (*P. triflora* Gilib.; *P. crocata* Michx.).—Fowl Blue-grass. Common in marshes.

P. pratensis L.—Kentucky Blue-grass. Common in meadows, along roadsides, etc.

P. scabrella (Thurb.) Benth. ex Vasey (*P. buckleyana* Nash).—Pine Blue-grass. Meadows, hills and open woods. Donavon, Kerrobert (UNS); Lake Athabaska (Raup).

P. secunda Presl (*P. sandbergii* Vasey).—Sandberg's Blue-grass. Abundant on dry plains in southwestern part of the area.

**Puccinellia distans* (L.) Parl.—Lax Alkali-grass. Weedy annual found occasionally on saline soil in vacant lots, waste places and around grain elevators.

P. nuttalliana (Schult.) Hitchc. (*P. airoides* (Nutt.) S. Wats. & Coult., not Koeler; *P. tenuiflora* (Turcz.) Scribn. & Merr.).—Nuttall's Alkali-grass. Common on saline flats in the prairie region.

Schedonnardus paniculatus (Nutt.) Trel.—Tumble Grass. Frequent on prairie. Moose Jaw, Swift Current, Val Marie (UNS); Eagle Creek and Johnstone Lake (CAN).

Schizachne purpurascens (Torr.) Swallen (*Avena striata* Michx.).—Purple Oat-grass. Common in aspen woods.

Scolochloa festucacea (Willd.) Link (*Fluminea festucacea* (Willd.) Hitchc.).—Common and widespread in shallow sloughs and marshes.

**Secale cereale* L.—Rye. Cultivated on sandy soil and escaped along roadsides.

**Setaria lutescens* (Weigel) Hubb.—Yellow Foxtail. Uncommon. Regina (UNS).

**S. viridis* (L.) Beauv.—Green Foxtail. Common weed in grain fields and along roadsides.

Sitanion hystrix (Nutt.) J. G. Smith.—Squirrel-tail. Southern border of the area. Val Marie (UNS).

Spartina gracilis Trin.—Alkali Cord-grass. Common in saline meadows on the plains.

S. pectinata Link (*S. michauxiana* Hitchc.; *S. cynosuroides* A. Gray, not Roth). —Prairie Cord-grass. Wet prairie and ditches in southeastern part of the area. Clearfield, Estevan, Gainsborough, Ralph, Red Jacket.

Sphenopholis intermedia (Rydb.) Rydb. (*S. pallens* of Fraser and Russell, not Scribn.).—Slender Wedge-grass. Frequent in moist places. Beaver Creek, Big River, Bjorkdale, Cypress Hills, Meadow Lake, McKague.

S. obtusata (Michx.) Scribn.—Prairie Wedge-grass. Widely distributed and fairly common in the area.

Sporobolus cryptandrus (Torr.) A. Gray.—Sand Dropseed. Frequent in very sandy soil. Saskatoon, Prince Albert, Nipawin, Mortlach (UNS, DAO).

S. heterolepis (A. Gray) A. Gray.—Prairie Dropseed. Moist to dry prairie. Manor, McKague (UNS, DAO); Beaver Hills, Touchwood (CAN).

Stipa columbiana Macoun (*S. nelsoni* Scribn.).—Columbia Needle-grass. Frequent on prairie hillsides in the southwestern part of our area. Cypress Hills, Swift Current (UNS, DAO, DASC).

S. comata Trin. & Rupr.—Needle-and-thread. Abundant on dry prairie.

S. comata var. *intermedia* Scribn. & Tweedy. (*S. tweedyi* Scribn.).—Tweedy's Needle-and-thread. Sandy hillsides. Saskatoon, St. Gregor (UNS).

S. richardsonii Link.—Richardson's Needle-grass. Edge of aspen groves. McKague, Cypress Hills, Meadow Lake (UNS, DAO).

S. spartea Trin.—Porcupine Grass. Frequent on dry prairie, hills and river banks in the eastern part of the area. Yorkton, Torch River (UNS).

S. spartea var. *curtiseta* Hitchc.—Common on dry plains; widely distributed. Mortlach, Saskatoon, St. Gregor, Swift Current, Cypress Hills.

S. viridula Trin.—Green Needle-grass. Common on dry prairie and plain.

Trisetum spicatum (L.) Richt.—Spike Trisetum. Pine woods in the Cypress Hills (UNS, DAO, DASC).

T. wolfii Vasey (*Graphiphorum wolfii* Vasey; *T. muticum* Scribn.).—Wolf's Trisetum. Dry pine woods in the Cypress Hills (UNS, DAO, DASC).

**Triticum aestivum* L. Wheat. The most important cereal grown in the province, chiefly the spring varieties. Often spontaneous along roadsides, not persistent.

CYPERACEAE—Sedge Family

Carex adusta Boott.—Browned Sedge. Scarce on sandy soil. Prince Albert National Park, Lac la Ronge, Meadow Lake (UNS, DAO).

C. aenea Fern.—Hay Sedge. Frequent in open woods and rocky slopes northward. McKague, Prince Albert, Waskesiu Lake (UNS, DAO).

C. alopecoidea Tuckerm.—Foxtail Sedge. Damp meadows. McKague (DAO, UNS, as *C. hoodii* in Fraser and Russell, ed. 1); Qu'Appelle Valley near Craven (DAO); Mortlach (DAO as *C. tenera* in Can. Field-Nat. 65:202, 1951).

C. aquatilis Wahlenb.—Water Sedge. Common in marshes; widely distributed.

C. aquatilis var. *substricta* Kükenth. (*C. substricta* (Kükenth.) Mack.).—Associated with the typical species; more common southward.

C. arcta Boott.—Bear Sedge. Swamps and wet woods. Amisk Lake (DAS).

C. assiniboinensis W. Boott.—Assiniboia Sedge. Wooded valleys. Moose Jaw, Lake Katepwa (UNS).

C. atherodes Spreng.—Awned Sedge. Common in borders of sloughs, lakes and streams; widely distributed.

C. athrostachya Olney.—Long-bracted Sedge. Moist meadows. Dana, Langham, McKague, Prince Albert National Park, Saskatoon, Cypress Hills.

C. aurea Nutt.—Golden Sedge. Frequent in woods and boggy meadows.

C. backii Boott (*C. durifolia* Bailey).—Tough-leaved Sedge. Frequent on wooded banks. Cypress Hills, Langham, McKague, Waskesiu Lake, Saskatoon.

C. bebbii Olney (*C. cristatella* of Fraser and Russell, not Britt.).—Bebb's Sedge. Common in moist meadows; widely distributed.

C. brevior (Dewey) Mack. (*C. molesta* Mack.).—Broad-fruited Sedge. Occasional on dry soil. Elbow, Buttress, Moose Jaw, Saskatoon, Swift Current, Tickfield (UNS); Cypress Hills (DAO); Bredenbury (CAN, GH, as *C. molesta*).

C. brunnescens (Pers.) Poir. (incl. var. *sphaerostachya* (Tuckerm.) Kükenth.).—Brownish Sedge. Frequent in coniferous woods northward. McKague, Crooked River (UNS); Lake Athabaska (Raup).

C. buxbaumii Wahlenb.—Brown Sedge. In swamps northward. Lake Athabaska (Raup); Candle Lake (DAO).

C. canescens L. (incl. var. *subloliacea* Laestad).—Hoary Sedge. Occasional in swamps and bogs northward. McKague (UNS, DAO); Lake Athabaska (Raup).

C. capillaris L. var. *elongata* Olney (*C. capillaris* f. *major* Kükenth., not var. *major* Drej.).—Hair-like Sedge. Occasional in wet woods. Macdowall, McKague, Pike Lake, Waskesiu Lake, Cypress Hills. Typical *C. capillaris* is a low-grown arctic and alpine race.

C. capitata L.—Capitate Sedge. Swamps. Methye River (CAN); Candle Lake (DAO); Amisk Lake (UNS).

C. chordorrhiza Ehrh. ex L.f.—Prostrate-stemmed Sedge. Occasional in bogs northward. McKague, Waskesiu Lake, Candle Lake (UNS, DAO); Lake Athabaska (Raup).

C. concinna R. Br.—Elegant Sedge. Occasional in moist spruce woods. McKague, Macdowall, Prince Albert (UNS, DAO); Cumberland House (CAN).

C. crawei Dewey.—Crawe's Sedge. Shore of Moose Mtn. Creek at Oxbow (DAS).

C. crawfordii Fern.—Crawford's Sedge. Occasional in moist places and sandy shores. McKague, Montreal Lake, Meadow Lake.

C. deflexa Hornem.—Deflexed Sedge. On outcrops of the Precambrian Shield. Lac la Ronge (DAO); Lake Athabaska (Raup).

C. deweyana Schw.—Dewey's Sedge. Common in woods; widely distributed.

C. diandra Schrank.—Two-stamened Sedge. Common in marshes and bogs.

C. dioica L. var. *gynocrates* (Wormskj.) Ostenfeld. (*C. gynocrates* Wormskj.).—Northern Bog Sedge. Common in wet spruce woods. Typical *C. dioica* is European.

C. disperma Dewey.—Soft-leaved Sedge. Common in swamps and bogs northward.

C. douglasii Boott.—Douglas' Sedge. Frequent in moist depressions on prairie.

C. eburnea Boott.—Bristle-leaved Sedge. Scarce in moist woods. Elbow, Langham, Saskatoon (UNS).

C. exsiccata Bailey.—Western Inflated Sedge. Bank of the Montreal River at Lac la Ronge (DAS, DAO).

C. festivella Mack.—Dark-fruited Sedge. Occasional in moist meadows. McKague, Melfort, Prince Albert National Park, Tisdale, Cypress Hills.

C. filifolia Nutt.—Thread-leaved Sedge. Common on exposed hillsides in the prairie region.

C. foena Willd (*C. siccata* Dewey).—Dry-spike Sedge. Common on dry, rocky and sandy soil in wooded areas.

C. glacialis Mack.—Glacier Sedge. Rare on rocky ledge at Lake Athabaska (Raup).

C. hassei Bailey (*C. garberi* Fern. var. *bifaria* Fern.).—Hasse's Sedge. Occasional in swamps through the coniferous forest. McKague, Pike Lake, Wallwort, Waskesiu Lake, Candle Lake, Cypress Hills (UNS, DAO).

C. heleonastes Ehrh. ex L.f.—Hudson Bay Sedge. Occasional in swamps northward. Candle Lake, Waskesiu Lake, Lac la Ronge, McKague (UNS, DAO).

C. hoodii Boott.—Hood's Sedge. Moist open slope of the Cypress Hills (UNS, DAO).

C. hookeriana Dewey.—Hooker's Sedge. Occasional on dry open banks. Buffalo Lake, McKague, Pike Lake, Saskatoon, Wallwort, Cypress Hills.

C. houghtonii Torr.—Houghton's Sedge. Occasional on sandy soil northward. Emma Lake, Prince Albert National Park, Tallpines, Candle Lake, Lac la Ronge.

C. hystricina Muhl.—Porcupine Sedge. Springy place in woods; rare. Pike Lake (UNS).

C. interior Bailey.—Inland Sedge. Common in bogs of the forested region.

C. lacustris Willd. (*C. riparia* Curtis var. *lacustris* (Willd.) Kükenth.).—Lakebank Sedge. Marshy shores of lakes and rivers. McKague, Montreal Lake, Prince Albert National Park, Redberry.

C. laeviconica Dewey.—Glaborus-fruited Sedge. Scarce in wet meadows. Moose Jaw, Prince Albert, Waskesiu, Qu'Appelle Valley near Craven (UNS).

C. lanuginosa Michx. (*C. lasiocarpa* var. *latifolia* (Böck.) Gilly). Wooly Sedge.—Common on borders of lakes.

C. lasiocarpa Ehrh. var. *americana* Fern. (*C. filiformis* Amer. auth., not L.).—Hairy-fruited Sedge. Frequent in swamps northward.

C. lenticularis Michx.—*Lenticular* Sedge. Rocky shores of lakes in the Precambrian Shield. Lac la Ronge (DAO); Lake Athabaska (Raup).

C. leptalea Wahlenb.—Bristle-stalked Sedge. Common in wet coniferous woods.

C. limosa L.—Mud Sedge. Occasional in bogs. Crooked River, McKague, Prince Albert, Waskesiu Lake (UNS, DAO).

C. livida (Wahlenb.) Willd.—Livid Sedge. Scarce in bogs northward. McKague, Pike Lake, Prince Albert (UNS, DAO).

C. loliacea L.— An arctic species, ranging southward into the forested region. Lac la Ronge (DAO); Lake Athabaska (Raup).

C. macloviana D'Urville ssp. *pachystachya* (Cham.) Hultén (*C. pachystachya* Cham.).—Thick-seeded Sedge. Wet places in the Cypress Hills (UNS, DAO).

C. meadii Dewey (*C. tetanica* Schk. var. *meadii* (Dewey) Bailey).—File Hills and Qu'Appelle Valley (CAN).

C. microptera Mack.—Small-winged Sedge. Springy places in shade. Cypress Hills (DAO); Sutherland, North Battleford (DAS).

C. nigromarginata Schw. var. *elliptica* (Boott) Gleason (*C. peckii* E. C. Howe).—Peck's Sedge. Common in woods; widely distributed.

C. norvegica Retz. ssp. *inferalpina* (Wahlenb.) Hultén (*C. vahlii* Schk. var. *inferalpina* (Wahlenb.) Fern.; *C. media* R. Br.; *C. angarae* Steud.).—Alpine Sedge. Occasional in damp woods. McKague, Prince Albert National Park, Tallpines (UNS, DAO); Methye Portage (CAN). Typical *C. norvegica* is a low-grown arctic race of eastern North America and Eurasia.

C. obtusata Lilj.—Blunt Sedge. Common on dry prarie.

C. oederi Retz. var. *viridula* (Michx.) Kükenth. (*C. viridula* Michx.).—Green Sedge. Occasional in bogs. Cypress Hills, Nipawin, Golburn, Emma Lake, Pike Lake, Prince Albert National Park, Saskatoon.

C. oligosperma Michx.—Few-seeded Sedge. Methye Portage near Lat. 57°N. (CAN); Lake Athabaska (Raup).

C. parryana Dewey (*C. hallii* Olney).—Parry's Sedge. Occasional in moist meadows. Wadena, Muenster, Sinnett, Peesane (UNS, DAO); Greighton near Flin Flon (DAS, DAO).

C. paupercula Michx. var. *irrigua* (Wahl.) Fern.—Bog Sedge. Occasional in bogs through the northern coniferous forest. Bjorkdale, Crooked River, Pre Ste. Marie, Prince Albert.

C. pedunculata Muhl.—Long-stalked Sedge. Cumberland House on the Saskatchewan River, collected by John Richardson (GH).

C. pensylvanica Lam. var. *digyna* Boeckl. (*C. heliophila* Mack.).—Sun-loving Sedge. Common on dry prairie.

C. petasata Dewey.—Caespitose Sedge. On dry, grassy slopes of the Cypress Hills (UNS, DAO).

C. physocarpa Presl.—Bubble Sedge. Damp crevices on shore of Lake Athabaska (Raup).

C. praegracilis W. Boott (*C. camporum* Mack.; *C. marcida* Boott, not J. F. Gmel.). —Graceful Sedge. Common in moist meadows.

C. prairea Dewey (*C. diandra* var. *ramosa* (Boott) Fern.).—Prairie Sedge. Frequent in bogs. Lac Vert, Macdowall, McKague, Pike Lake, Prince Albert, Saskatoon (UNS, DAO).

C. praticola Rydb. (*C. pratensis* Drejer, not Host).—Northern Meadow Sedge. Frequent on prairie and openings in woods. Buttress, Elbow, Langham, Saskatoon, McKague, Cypress Hills, Cadillac.

C. pseudo-cyperus L.—Cyperus-like Sedge. Marshy lake shores. McKague (UNS, DAO); Amisk Lake (DAS).

C. raymondii Calder (*C. atratiformis* of western auth., not Britt.).—Raymond's Sedge. Occasional in moist meadows northward. Prince Albert National Park, Shipman, McKague, Tallpines, Villardville, Candle Lake.

C. raynoldsii Dewey.—Raynolds' Sedge. Semi-wooded slope on the Cypress Hills (UNS, DAO).

C. retrorsa Schw.—Retrorse Sedge. Occasional around springy places in woods. Crooked River, McKague, Speddington, Shipman, Waskesiu Lake, Weyburn.

C. richardsonii R. Br.—Richardson's Sedge. Occasional on dry ground in semi-wooded areas. Love, McKague, Muenster, Prince Albert.

C. rossii Boott (*C. deflexa* var. *rossii* (Boott) Bailey).—Ross' Sedge. Common on shaded banks in the prairie region.

C. rostrata Stokes (*C. utriculata* Boott; *C. inflata* Huds.).—Beaked Sedge. Common in marshes along lakes and rivers.

C. sartwellii Dewey.—Sartwell's Sedge. Common in wet meadows; widely distributed.

C. saximontana Mack.—Mountain Sedge. Wooded banks. Elbow, Moose Jaw, Tilney, Saskatoon (UNS). Perhaps not specifically distinct from *C. durifolia*.

C. scirpoidea Michx.—Scirpus-like Sedge. An arctic and alpine species. Nistum Lake (DAS); Lake Athabaska (Raup).

C. scirpoidea var. *scirpiformis* (Mack.) O'Neill & Duman (*C. scirpiformis* Mack).—Frequent in wet meadows and bogs. Saskatoon, Prince Albert, Muenster, Swift Current, Neville, Humboldt, Mortlach.

C. scoparia Schk.—Pointed Broom Sedge. Moist meadows, thickets and open woods. Carnduff, Saskatoon (UNS).

C. simulata Mack.—Mimic Sedge. Scarce in springy places. Pike Lake, Yorkton (UNS); Cypress Hills (DAO).

C. sprengelii Dewey.—Sprengel's Sedge. Common in rich woods; widely distributed.

C. stenophylla Wahl. ssp. *eleocharis* (Bailey) Hultén (*C. eleocharis* Bailey).—Involute-leaved Sedge. Common on dry prairie.

C. sterilis Willd.—Sterile Sedge. Occasional in bogs northward. Macdowall, Prince Albert, Waskesiu Lake (UNS); Nipawin (DAO).

C. stipata Muhl.—Awl-fruited Sedge. Frequent in wet woods; widespread.

C. supina Willd. ex Wahlenb. ssp. *spaniocarpa* (Steud.) Hultén.—Weak Arctic Sedge. Rare on rocky and sandy slopes at Lake Athabaska (Raup).

C. sychnocephala Carey.—Dense Long-beaked Sedge. Widespread in meadows. McKague, Tallpines, Cypress Hills.

C. tenera Dewey (*C. tincta* of Fraser & Russell, ed. 3, not Fern.).—Straw Sedge. Frequent in moist meadows; widely distributed.

C. tenuiflora Wahlenb.—Sparse-flowered Sedge. Occasional in bogs northward. Crooked River, Waskesiu Lake (UNS); Lake Athabaska (Raup).

C. tonsa (Fern.) Bickn. (*C. umbellata* Schk. var. *tonsa* Fern.).—Deep Green Sedge. Frequent in dry sandy pine woods northward. Prince Albert, Methye Portage, Nipawin, Candle Lake, Ile a la Cross (UNS, DAO); Lake Athabaska (Raup).

C. torreyi Tuckerm. (*C. abbreviata* Prescott).—Torrey's Sedge. Common on moist prairie.

C. trisperma Dewey.—Three-fruited Sedge.—Moist birchwoods. Candle Lake (DAS).

C. umbellata Schk. (*C. abdita* Bickn.).—Umbellate Sedge. Rocky outcrops and sandy pine woods northward. Lac la Ronge (UNS, DAO).

C. vaginata Tauscher (*C. saltuensis* Bailey).—Sheathed Sedge. Frequent in wet coniferous woods northward.

C. vesicaria L. (*C. raeana* Boott).—Blister Sedge. Rare in moist places. Trossachs (UNS); Methye Portage, collected by John Richardson (CAN, as *C. raeana*).

C. vulpinoidea Michx.—Fox Sedge. Occasional in damp meadows and shores northward. Montreal Lake, Prince Albert National Park (UNS); Ile a la Crosse (DAO).

C. xerantica Bailey.—White-scaled Sedge. Occasional on prairie. Buttress, Gainsborough, Humbolt, McKague, Saskatoon, Trossachs, Cypress Hills, Hague.

Cladium mariscoides (Muhl.) Torr. (*Mariscus mariscoides* (Muhl.) Kuntze).—Twig Rush. In bog 6 miles north of Dahlton, Lat. 52°25′ N; Long. 104°5′ W (UNS, DAO).

Cyperus inflexus Muhl. (*C. aristatus* Böck., not Rottb.).—Awned Cyperus. Shore of slough at Mortlach (DAO, DASC); Amisk Lake (DAO).

C. schweinitzii Torr.—Schweinitz's Cyperus. Sandy soil. Cutnife, Elbow (UNS).

C. strigosus L.—Straw-colored Cyperus. Wet meadows and shores at Watrous (DAO).

Eleocharis acicularis (L.) Roem. & Schult.—Needle Spike-rush. Common in shallow water and muddy shores. Svenson in Rhodora 31:201, 1929 gives the range of *Eleocharis wolfii* from Indiana to Kansas and Louisiana. In Rhodora 41:18, 1939, Svenson cites a specimen of *E. wolfii* from Crane Lake, Assiniboia, Macoun 7548 (NY). This specimen likely represents an immature *E. acicularis.*

E. compressa Sulliv. (*E. acuminata* (Muhl.) Nees).—Flat-stem Spike-rush. In calcarious bogs usually associated with *E. pauciflora* var. *fernaldii.* A. J. Breitung: McKague 217, Wallwort 1380, Nipawin 6030 (DAO, as *E. uniglumis*); Bredenbury, Macoun & Herriot 73041 (CAN, GH); Moose Jaw Creek, Macoun 32174 (CAN). Specimens not in herb. CAN but recorded by Svenson in Rhodora 34:216, 1932 from Moose Mt. Creek, Macoun 301 and from Souris Plain, Macoun 6.

E. palustris (L.) Roem. & Schult. (*E. mamillata* Lindb. f.: *E. macrostachya* Britt.; *E. uniglumis* of auth., not Schultes).—Creeping Spike-rush. Common in marshes and shores of lakes and streams. *E. palustris,* sens. lat. is an atrocious typus polymorphus; from which a number of supposed species have been segregated, that appear to intergrade so freely as to be in most cases quite untenable as separate taxonomic units. Svenson in Rhodora 41:58, 1939, states: "*E. macrostachya* was fortunately based on excellent specimens around which western material can be aligned. I have seen a wealth of herbarium material which falls naturally into about a dozen recognized but intergrading races, showing varied shape, color and rigidity of spikes." According to Svenson, all of our material belongs to *E. macrostachya.* He does not recognize *E. uniglumis* in our area, considering it an arctic species reaching its southern limit in eastern America on the Mountains of Newfoundland. On the other hand, Fernald identified specimens from Long Lake, Herzel, Crane Lake and north of Prince Albert (CAN) as *E. uniglumis* having narrow, dark brown spikes. I have collected such specimens along gravelly shores of streams: A. J. Breitung, Cypress Hills 5155 (DAO, as *E. calva*); Hudson Bay Junction 764, Nipawin 5982 (DAO, as *E. uniglumis*).

E. pauciflora (Lightf.) Link var. *fernaldii* Svenson (*E. fernaldii* (Svenson) Love).—Few-flowered Spike-rush. Occasional in calcarious bogs and shores. Bredenbury (CAN); Cypress Hills (CAN, DAO); McKague, Wallwort (UNS, DAO); Amisk Lake (DAS); Lake Athabaska (Raup). According to Love in Svensk Bot. Tids. 48:218-219, 1954, the European *E. pauciflora* is 2n: about 100 and the American plant is 2n: 80.

Eriophorum alpinum L. (*Leococoma alpina* (L.) Rydb.; *Scirpus hudsonianus* (Michx.) Fern.).—Alpine Cotton-grass. Bogs in the northern coniferous. Golburn, McKague, Nipawin, Peesane, Lac la Ronge (UNS, DAO); Lake Athabaska (Raup).

E. angustifolium Honckeny.—Tall Cotton-grass. Common in spruce swamps.

E. brachyantherum Trautv. (*E. opacum* (Björnstr.) Fern.).—Close-sheathed Cotton-grass. Occasional in spruce swamps northward. McKague, Prince Albert, Waskesiu Lake (UNS, DAO); Lake Athabaska (Raup).

E. chamissonis C. A. Mey. forma *albidum* (F. Nyl.) Fern. (*E. russeolum* Fries var. *albidum* F. Nyl.; *E. russeolum* var. *leocothrix* (Blomgr.) Hultén; *E. medium* Anderss.). —Chamisso's Cotton-grass. Occasional in swamps northward. Crooked River, McKague, Waskesiu Lake (UNS, DAO); Lake Athabaska (Raup).

E. gracile Koch (*E. tenellum* of Raup, l.c. 211, not Nutt.).—Slender Cotton-grass. Scarce in spruce swamps. McKague, Macdowall (UNS, DAO); Lake Athabaska (Raup).

E. vaginatum L. ssp. *spissum* (Fern.) Hultén (*E. spissum* Fern.; *E. callitrix* of various auth., not Cham.).—Loose-sheathed Cotton-grass. Occasional in spruce swamps northward. McKague, Crooked River, Prince Albert, Prince Albert National Park (UNS, DAO); Lake Athabaska (Raup).

E. viridicarinatum (Engelm.) Fern.—Thin-leaved Cotton-grass. Common in bogs.

Rhynchospora alba (L.) Vahl.—White Beaked-rush. Scarce in bogs northward. Dahlton, Prince Albert, Nipawin (UNS, DAO).

R. capillacea Torr. (*R. fusca* of Fraser and Russell, not Ait. f.).—Hair-like Beaked-rush. Rare in bogs northward. Nipawin, Wallwort (UNS, DAO).

Scirpus acutus Muhl. (*S. occidentalis* (S. Wats.) Chase).—Hard-stem Bulrush. Occasional in marshy shores of ponds and lakes. Heart Lakes, Nipawin, Hossier, Crane Lake, Pike Lake, Yorkton (UNS, DAO). Specimens from Pike Lake and Yorkton were determined by Alan A. Beetle of the University of Wyoming, Laramie.

S. americanus Pers.—Three-square Bulrush. Common around alkaline sloughs in the prairie region.

S. caespitosus L. var. *callosus* Bigel.—Tufted Club-rush. Frequent in bogs of the northern coniferous forest. Dahlton, Nipawin, Prince Albert (UNS); Lake Athabaska (Raup).

S. clintonii A. Gray.—Clinton's Rush. Dry, gravelly, open woods; rare. Meadow Lake (DAO).

S. cyperinus (L.) Knuth (*S. atrocinctus* Fern.).—Wool-grass. Occasional in swamps northward. Meadow Lake, Prince Albert, Prince Albert National Park, Turtle Lake (UNS, DAO); Lake Athabaska (Raup).

S. fluviatilis (Torr.) A. Gray.—River Bulrush. Marshy shores. Pike Lake (UNS; DAO); Indian Head (CAN).

S. microcarpus Presl (*S. rubrotinctus* Fern.).—Small-fruited Bulrush. Occasional in swamps; widely distributed. McKague, Cypress Hills; Lake Athabaska (Raup).

S. nevadensis S. Wats.—Nevada Bulrush. Wet alkaline soil on prairie. Redberry Lake, Saskatoon, Vonda Lake (UNS); Cypress Hills and Johnstone Lake (CAN).

S. paludosus A. Nels.—Prairie Bulrush. Common in alkaline marshes of the prairie region.

S. pumilus Vahl var. *rollandi* (Fern.) Beetle. (*S. rollandi* Fern.). In a bog at Sutherland (UNS). See: Amer. Midl. Nat. 41:483 (1949).

S. rufus (Huds.) Schrad. var. *neogaeus* Fern.—Red Club-rush. Scarce in marshes. and bogs of the prairie region. Pike Lake, Sutherland (UNS).

S. validus Vahl.—Great Bulrush. Common in borders of lakes and sloughs.

ARACEAE—Arum Family

Acorus calamus L.—Sweet Flag. Occasional in marshes. Bjorkdale, McKague, Pike Lake, Prince Albert National Park, Tisdale.

Calla palustris L.—Marsh Calla. Occasional in marshes and bogs northward. Lake Athabaska (Raup); Bjorkdale, Christopher Lake, Montreal Lake, Prince Albert National Park (UNS).

LEMNACEAE—Duckweed Family

Lemna minor L.—Lesser Duckweed. Floating on quiet ponds; common.

L. trisulca L.—Ivy-leaved Duckweed. Common in lakes and streams. Plant usually submerged.

Spirodela polyrhiza (L.) Schleiden.—Larger Duckweed. Floating on quiet water. Prince Albert National Park (UNS); Meadow Lake (DAO).

JUNCACEAE—Rush Family

Juncus alpinus Vill. var. *rariflorus* (Hartm.) Hartm. (var *insignis* Fries; var. *fuscescens* Fern.; *J. nodulosus* Wahlenb.; *J. richardsonianus* Schult.).—Richardson's Rush. Common on wet calcareous shores, in bogs and marshes. A variable circumboreal species forms of which have been segregated as separate species, subspecies and varieties.

J. balticus Willd. var. *montanus* Engelm. (*J. ater* Rydb.).—Baltic Rush. Common in wet meadows. Var. *littoralis* Engelm. occurs at Lake Athabaska (Raup). A variable circumboreal species segregated into several varieties by some authors.

J. brevicaudatus (Engelm.) Fern.—Narrow-panicled Rush. Springy places. Lake Athabaska (Raup); Meridian Lake (DAS); Nipawin (DAO, as *J. acuminatus*).

J. bufonius L.—Toad Rush. Frequent on sandy shores of lakes and streams.

J. confusus Cov. (*J. tenuis* var. *congestus* Engelm., in part).—Few-flowered Rush. Scarce on prairie. Cypress Hills (DAO); Saskatoon (UNS).

J. ensifolius Wikstr.—Equitant-leaved Rush. Springy places in the Cypress Hills (UNS, DAO).

J. filiformis L.—Thread Rush. Sand dunes and wet shores of Lake Athabaska (Raup).

J. longistylis Torr.—Long-styled Rush. Common in wet meadows.

J. nodosus L.—Knotted Rush. Common along shores of lakes and streams.

J. saximontanus A. Nels. (*J. ensifolius* var. *major* Hook.; *J. mertensianus* of Fraser & Russell, not Bong.).—Rocky Mountain Rush. Occasional along springs and brooks in the Cypress Hills (UNS, DAO).

J. stygius L. ssp. *americanus* (Bucheneau) Hultén (var *americanus* Bucheneau).—American Bog Rush. Boggy shore of Lake Athabaska (Raup).

J. tenuis Willd. var *multicornis* E. Mey. (*J. macer* S. F. Gray).—Path Rush. In wet places. Prince Albert National Park, Montreal Lake (UNS).

J. tenuis var. *dudleyi* (Wieg.) Hermann (*J. dudleyi* Wieg.).—Dudley's Path Rush. Common in ditches, open woods and especially in paths and on roadsides.

J. torreyi Cov.—Torrey's Rush. Sandy shores. Mortlach, Saskatoon (UNS); Lake Athabaska (Raup).

J. vaseyi Engelm.—Vasey's Rush. Damp thickets and sandy shores. Montreal Lake (UNS); Meadow Lake (DAO); Lake Athabaska (Raup).

Luzula acuminata Raf. (*L. saltuensis* Fern.).—Hairy Wood-rush. Moist woods. Meadow Lake (DAO).

L. multiflora (Retz.) Lej. (*L. campestris* (L.) DC. var. *multiflora* (Retz.) Celak.).—Many-flowered Wood-rush. Frequent in dry woods. McKague (UNS); Cypress Hills, Meadow Lake, Candle Lake (DAO).

L. parviflora (Ehrh.) Desv.—Small-flowered Wood-rush. Moist woods northward. Candle Lake, Meadow Lake, Ile a la Crosse, Lac la Ronge (DAO).

LILIACEAE—Lily Family

Allium cernuum Roth (*A. recurvatum* Rydb.).—Nodding Onion. Dry hillsides and rocky slopes in the southern part of the area. Carnduff (UNS, DASC); Cypress Hills (DAO).

A. schoenoprasum L. var. *sibiricum* (L.) Hartm. (*A. sibiricum* L.).—Siberian Chives. Damp sandy and gravelly shore of Lake Athabaska (Raup); Amisk Lake (DAS).

A. stellatum Fraser ex Ker.—Pink-flowered Onion. Frequent on prairie in the eastern part of the area.

A. textile A. Nels. & Macbr. (*A. geyeri* of Fraser and Russell, not S. Wats.).—Prairie Onion. Common on dry prairie and exposed hills. A single, rather worn specimen, lacking bulb, collected in the Cypress Hills by Macoun 27430 (CAN) as *A. stellatum* is best placed in *A. textile*.

Disporum trachycarpum (S. Wats.) Hook. & Benth.—Fairy Bells. Common in woods.

Lilium philadelphicum L. var. *andinum* (Nutt.) Ker. (*L. umbellatum* Pursh).—Western Red Lily. Frequent in open woods and moist prairie. This is the floral emblem of Saskatchewan. See: Canadian Nature 16(2):42-47, 1954.

Mianthemum canadense Desf. var. *interius* Fern.—Two-leaved Solomon's Seal. Common in woods northward.

Smilacina racemosa (L.) Desf. var. *amplexicaulis* (Nutt.) S. Wats. (*Vagnera amplexicaulis* (Nutt.) Morong).—Western Solomon's Seal. Occasional on wooded slopes in the Cypress Hills (UNS, DAO, DASC).

S. stellata (L.) Desf. (*V. stellata* (L.) Morong).—Star-flowered Solomon's Seal. Common in woods and on open slopes.

S. trifoliata (L.) Desf. (*V. trifolia* (L.) Morong).—Three-leaved Solomon's Seal. Occasional in swamps and bogs. Bjorkdale, Crooked River, McKague, Prince Albert, Wakesiu Lake (UNS, DAO, DAS); Lake Athabaska (Raup).

Smilax herbacea L. var. *lasioneuron* (Hook.) A. DC. (*Nemexia lasioneuron* (Hook.) Rydb.).—Hairy-nerved Smilax. Frequent on alluvial banks and in thickets.

Streptopus amplexifolius (L.) DC.—Clasping-leaved Twisted-stalk. Rich, moist woods. Cypress Hills (UNS, DAO, DASC); Meadow Lake (DAO).

Tofieldia glutinosa (Michx.) Pers. (*T. intermedia* [*T. glutinosa* ssp. *montana* C. L. Hitchc.] of report from Sask. in Fl. Rocky Mts. & Adj. Pl., not Rydb.).—Sticky False Asphodel. In bogs northward. McKague, Prince Albert (UNS, DAO). [*Tofieldia palustris* Huds. (*T. pusilla* (Michx.) Pers.) probably occurs across the extreme northern part of Saskatchewan. This species was collected by Raup, lc. 224, near Sand Point on Lake Athabaska, Alberta, and by Baldwin, Bull. No. 128:24, 1953, Ann. Rep. Nat. Mus. for the fiscal year 1951-52, at Nueltin Lake in northern Manitoba.]

Trillium cernuum L.—Nodding Trillium. Damp woods at Runnymede near east boundary (UNS).

Zygadenus elegans Pursh (*Anticlea elegans* (Pursh) Rydb.; *Z. chloranthus* Richards.).—Smooth Camas. Common in moist meadows. The closely related eastern *Z. glaucus* Nutt., J. Acad. Philad. 7:56, 1834, is best regarded as a subspecies of *Z elegans*. Some authorities have wrongly applied *Z. choranthus* to the eastern *Z. glaucus*.

Z. venosus S. Wats. var. *gramineus* (Rydb.) Walsh (*Toxicoscordion gramineum* Rydb.; *Z. intermedius* Rydb.).—Death Camas. Damp meadows on plains in SW Sask. Cypress Hills, Ravenscrag, Swift Current, Maple Creek, Mortlach.

AMARYLLIDACEAE—Amaryllis Family

Hypoxis hirsuta (L.) Cov.—Hairy Star Grass. Meadows and open woods. Buchanan, Yorkton (UNS).

IRIDACEAE—Iris Family

Sisyrinchium montanum Greene (*S. angustifolium* of western auth., not Mill).—Common Blue-eyed Grass. Common in meadows; widely distributed.

S. mucronatum Michx.—Mucronate Blue-eyed Grass. Occasional in the prairie region. Muenster, Sutherland, Patience Lake, Indian Head, Broadview (UNS, DAS); 40 miles east of Saskatoon, John Macoun & Wm. Herriot, No. 70390, July 23, 1906 (CAN, as *S. septentrionale*).

ORCHIDACEAE—Orchid Family

Calypso bulbosa (L.) Oakes (*C. borealis* Salisb.; *Cytheria bulbosa* (L.) House).—Venus' Slipper. In pine woods. Cypress Hills, Bjorkdale, Torch River (UNS, DAO); Lake Athabaska (Raup).

Corallorhiza maculata Raf. (*C. multiflora* Nutt.).—Spotted Coral-root. Occasional in rich woods. Cypress Hills, Emma Lake, Langbank, McKague, Theodore (UNS, DAO).

C. striata Lindl.—Striped Coral-root. Rich woods. Cypress Hills, Wallwort, Moose Mtn., Kelliher, Langbank (UNS, DAO).

C. trifida Chatelain (*C. innata* R. Br.; *C. corallorhiza* (L.) Karst.).—Early Coral-root. Frequent in woods; widely distributed.

Cypripedium acaule Ait. (*Fissipes acaulis* (Ait.) Small).—Stemless Lady's Slipper. Sandy and rocky pine woods northward. Lac la Ronge (UNS); Lake Athabaska (Raup).

C. arietinum R. Br. (*Criosanthes arietina* (R. Br.) House).—Ram's-head Lady's Slipper. Damp woods. Prince Albert (UNS).

C. calceolus L. var. *pubescens* (Willd.) Correll (*C. parviflorum* Salisb.; *C. montanum* of reports from Sask., not Dougl.).—Yellow Lady's Slipper. Frequent in and

around woods. Our plant is by some authorities segregated as *C. calceolus* var. *parviflorum* (Salisb.) Fern. However, D. S. Correll in *Native Orchids of North America* 1950, considers it as merely an ecological entity.

C. passerinum Richards.—Sparrow's-egg Lady's Slipper. Along springs in coniferous woods. Cypress Hills, McKague, Waskesiu Lake, Bjorkdale, Macdowall (UNS, DAO).

Goodyera oblongifolia Raf. (*G. decipiens* (Hook.) Hubbard; *G. menziesii* Lindl.). —Menzie's Rattlesnake Plantain. Pine Woods. Cypress Hills (UNS, DAO).

G. repens (L.) R. Br. var. *ophioides* Fern. (*G. ophioides* (Fern.) Rydb.; *Peramium ophioides* (Fern.) Rydb.).—Lesser Rattlesnake Plantain. Moist coniferous woods. Waskesiu Lake, McKague, Emma Lake (UNS); Lake Athabaska (Raup).

Habenaria dilatata (Pursh) Hook. (*Orchis dilatata* Pursh; *Platanthera dilatata* (Pursh) Lindl. ex Beck.; *Limnorchis dilatata* (Pursh) Rydb.).—White Bog Orchid. Cold bogs in coniferous woods. Prince Albert, Pike Lake, Macdowall (UNS); McKague, Cypress Hills (DAO).

H. hyperborea (L.) R. Br. (*H. huronensis* (Nutt.) Spreng.; *P. hyperborea* (L.) Lindl.; *L. viridiflora* (Cham.) Rydb.).—Green-flowered Orchid. Common in swamps; widely distributed.

H. obtusata (Banks ex Pursh) Richards. (*P. obtusata* (Pursh) Lindl.; *Lysiella obtusata* (Pursh) Rydb.).—Small Northern Bog Orchid. Frequent in wet spruce woods.

H. orbiculata (Pursh) Torr. (*P. orbiculata* (Pursh) Lindl.; *Lysias orbiculata* (Pursh) Rydb.).—Large Round-leaved Orchid. Moist coniferous woods northward. Torch River (UNS); Amisk Lake (DAS).

H. viridis (L.) R. Br. ssp. *bracteata* (Muhl. ex Willd.) R. T. Clausen (var. *bracteata* (Muhl.) A. Gray; *H. bracteata* (Muhl.) R. Br.; *H. viridis* var. *interjecta* Fern.; *Coeloglossum viride* (L.) Hartm. ssp *bracteatum* (Muhl.) Hultén).—Long-bracted Orchid. Common in meadows and borders of sandy woods.

Liparis loeselii (L.) Richard (*Malaxis loeselii* (L.) Sw.).—Bog Tway-blade. Bogs and swamps. Dahlton (UNS); McKague (DAO).

Listera borealis Morong (*Ophrys borealis* (Morong) Rydb.; *L. convallarioides* of reports from Sask., not Torr.).—Northern Tway-blade. Springy places in spruce woods. Cypress Hills, McKague, Prince Albert (UNS, DAO); Waskesiu Lake (UNS, DAS).

L. cordata (L.) R. Br. (*O. cordata* L.).—Heart-leaved Tway-blade. Cool spruce woods. Cypress Hills, McKague, Crooked River (UNS, DAO).

Malaxis monophyllos (L.) Sw. var. *brachypoda* (A. Gray) Morris & Eames (*M. brachypoda* (A. Gray) Fern.; *M. unifolia* of Sask. reports, not Michx.).—Adder's Mouth. In moist coniferous woods northward. Waskesiu Lake (UNS).

Orchis rotundifolia Banks ex Pursh.—Round-leaved Orchis. Frequent in swamps and wet woods; widely distributed.

Spiranthes gracilis (Bigel.) Beck (*Ibidium gracile* (Bigel.) House.—Slender Ladies' Tresses. Scarce in sandy pine woods northward. Prince Albert, Waskesiu Lake (UNS); Meadow Lake (DAO).

S. romanzoffiana Cham. & Schl. (*S. stricta* (Rydb.) A. Nels.; *I. strictum* (Rydb.) House).—Hooded Ladies' Tresses. Occasional in swamps. Cypress Hills, McKague, Beaver Creek, Prince Albert, Red Pheasant, Waskesiu Lake.

DICOTYLEDONEAE—Dicotyledons

SALICACEAE—Willow Family

Populus balsamifera L. (*P. tacamahacca* Mill.; *P. candicans* Ait.; *P. michauxii* Dode). —Balsam Poplar. Common in wet ground, usually near lakes and streams. Recent studies in *Populus*, supported by copious specimens, indicate the Canadian distribution of *P. angustifolia* James and *P. acuminata* Rydb., is in south-central Alberta. Some authorities now consider *P. acuminata* to be a hybrid between *P. angustifolia* and *P. sargentii*, since *P. acuminata* occurs only where the two supposed parent species are found.

P. sargentii Dode (*P. deltoides* var. *occidentalis* Rydb.; *P. besseyana* Dode; *P. deltoides* of Sask. reports, not Bartr. ex Marsh.).—Plains Cottonwood. Along streams in the prairie region. Swift Current, Lumsford Ferry, Saskatoon, Saskatchewan Landing, Bracken. Leaves on vigorous shoots of *P. sargentii* closely resemble the leaves of *P. deltoides*.

P. tremuloides Michx. (*P. aurea* Tidestr.).—Trembling Aspen. Abundant often forming pure stands of timber or associated with other tree species.

**Salix acutifolia* Willd. (*S. daphnoides* Vill.).—Sharp-leaved Willow. Cultivated for windbreaks in the prairie region.

S. alaxensis (Anderss.) Cov. var. *obovalifolia* Ball (*S. silicicola* Raup).—Felt-leaf Willow. Sand dunes and beach ridges around Lake Athabaska (Raup).

**S. alba* L.—White Willow. Planted as windbreaks and shade trees along streets. Var. *argentea* Wimmer (var. *sericea* Gaud.) and var. *vitellina* (L.) Stokes are the forms commonly planted. Some of the material may represent hybrids between *S. alba* and *S. fragilis*.

S. amygdaloides Anderss.—Peach-leaved Willow. Along streams. Bertwell, Hudson Bay Junction, Maple Creek, Riverhurst, Stewart Valley, Val Marie, Eastend (UNS); Cypress Hills (DAO).

S. arbusculoides Anderss. (*S. argyrocarpa* of western reports, not Anderss.).—Little-tree Willow. Slough margins and rocky shores northward.

S. arbusculoides var. *glabra* Anderss. (*S. saskatchewana* von Seemen; *S. tyrellii* Raup).—A glabrous form found among inland shifting sand dunes at Lake Athabaska (Raup).

S. athabascensis Raup (*S. fallax* Raup; *S. glauca* var. *glabrescens* of Fraser in Can. Field-Nat. 56:106, 1942, not Schn.; *S. glaucops* of Fraser and Russell, not Anderss.).—Athabaska Willow. Occasional in spruce swamps. Nipawin, McKague, Prince Albert National Park, McKague, Candle Lake (UNS, DAO, CAN).

S. bebbiana Sarg. (*S. rostrata* Richards., not Thuill.).—Beaked Willow. Abundant along margins of swamps and on well drained uplands.

S. bebbiana var. *perrostrata* (Rydb.) Schn. (*S. perrostrata* Rydb.).—Associated with the typical species but not readily distinguished from it.

S. brachycarpa Nutt. (incl. var. *psamophila* Raup; *S. stricta* (Anderss.) Rydb.; *S. desertorum* of Anderss., not Richards.).—Short-capsuled Willow. Occasional around calcareous sloughs and bogs. Cypress Hills (CAN); Spy Hill, Carmel (UNS); St. Gregor, Naicam, Crooked River, Prairie River (UNS, DAO); Wierdale, Meath Park, Candle Lake (DAO); Lake Athabaska (Raup).

S. candida Flügge.—Hoary Willow. Frequent in swamps, chiefly northward.

S. candida forma *denudata* (Anderss.) Rouleau (*S. candida* var. *denudata* Anderss.).—Occurs sparingly with the typical species.

S. caudata (Nutt.) Heller var. *parvifolia* Ball.—Whiplash Willow. Along Battle Creek at Fort Walsh in the Cypress Hills (DAO).

S. discolor Muhl.—Pussy Willow. Common in wet places, sometimes attaining tree size.

S. discolor var. *prinoides* (Pursh) Anderss.—Western Pussy Willow. This western race occurs in the Cypress Hills and is distinguished by having narrower and more serrulate leaves.

S. glauca L. (var. *acutifolia* (Anderss.) Schn.; var. *glabrescens* (Anderss.) Schn.; var. *aliceae* Ball; *S. glauca* var. *acutifolia* forma *poliophylla* Schn.; *S. desertorum* Richards.; *S. glaucops* Anderss.).—Gray Willow. Common in muskegs and damp shores around Lake Athabaska (Raup). Probably more widespread through the subarctic forest across the northern part of the area. In both Europe and America, *S. glauca* is exceedingly variable in leaf form and pubescens and in form and size of shrubs; there being no constant characters to separate the various forms described. The whole complex is best regarded as a single species, disguised in numerous phases.

S. humilis Marsh. (*S. discolor* var. *eriocephala* of Fraser and Russell, not Anderss.).—Low Willow. In sandy pine woods northward. McKague, Nipawin, Candle Lake (UNS, DAO). [The closely related *S. tristis* Ait. has been collected in extreme southwestern Manitoba near Lyleton (DAO), and it may possibly be found in the adjacent part of our area].

S. interior Rowlee (*S. longifolia* Muhl., not Lam.; *S. melanopsis* of Sask. reports, not Nutt.).—Sandbar Willow. Common on alluvial shores. Reports of *S. exigua* and *S. luteosericea* from our area represent young shoots of *S. interior* which are normally sericeous. New leaves following injury by insects, browsing animals or ice action along streams are sometimes densely silvery-silky resembling *S. interior* forma *wheeleri*.

S. interior var. *pedicellata* (Anderss.) Ball (*S. longifolia* var. *pedicellata* Anderss.).—Associated with the typical species but less common.

S. lasiandra Benth. (*S. lyallii* (Sarg.) Heller).—Red Willow. Frequent along water-

courses. Shore of the North Saskatchewan River at Langham, Prince Albert National Park (UNS, DAO); Wallwort, McKague, Golburn, Tisdale, Candle Lake, North Battleford, Meadow Lake, Beauval along the Beaver River 140 miles NE of Meadow Lake (DAO). Two specimens collected along the Saskatchewan River, one at Carleton House, by E. Bourgeau probably belong here. They are inadvertently referred to as *S. lucida* by Schneider, J. Arn. Arb. 1:16, 1919, in his discussion of *S. lasiandra*.

S. lasiandra var. *lancifolia* (Anderss.) Bebb.—This form has about the same range as the species in our area. Nipawin, Waskesiu Lake, Lac la Ronge (UNS, DAO); Meadow Lake, Meadow Lake Forest Reserve, Waterhen River (DAO).

S. lucida Muhl.—Shining Willow. Frequent along streams in central eastern Saskatchewan, Nipawin, Runciman, Leacross, Hudson Bay Junction, Greenbush, Prairie River. Individuals attaining tree size, up to 30 feet in height, were observed on alluvial river flat at crossing of the Leather River near Leacross. Specimens referred to var. *angustifolia* and var. *intonsa* by Fraser and Russell, do not compare well with material examined of these forms from east of the Great Lakes. I therefore refer all our Saskatchewan specimens to typical *S. lucida*.

S. lutea Nutt. (*S. eriocephala* and *S. rigida* of reports from Sask., not Muhl. nor Michx.).—Yellow Willow. Common on alluvial banks of lakes and streams. Plants of *S. eriocephala* (*S. rigida*), observed by the writer along the Ottawa River, Ontario, are quite different from anything found in Saskatchewan. Also the branchlets of the eastern plant are very brittle, breaking off readily at the junction. In *S. lutea* they are not brittle.

S. maccalliana Rowlee.—Velvet-capsuled Willow. Frequent in swamps of the wooded sections. It is of interest that *S. maccalliana, S. padophylla* (*S. pseudomonticola*), and *Betula occidentalis* are known to occur eastward to the James Bay Region. See: A. Dutilly, *et al.*, in Cont. Arctic Inst. Catholic Univ. Amer., Wash., No. 5F:69, 71, 73, 1954.

S. mackenzieana (Hook.) Barratt ex Anderss. (*S. turnorii* Raup).—Mackenzie Willow. In northwestern part of the province. Among shifting sand dunes along south shore of Lake Athabaska (Raup, as *S. turnorii*). In Canada, this species ranges from British Columbia to the foothills of Alberta, northward to the Mackenzie River and in the forested region eastward to northwestern Saskatchewan. The report of *Salix mackenzieana* from the Yukon by Porsild, Nat. Mus. Can. Bull. No. 121, Biol. Ser. 41:143, 1951, should be referred to *S. padophylla*. *S. mackenzieana* has also been confused with *S. eriocephala* Michx. and consequently reported from as far east as Manitoba by C. W. Lowe, *List of the Flowering Plants . . . of Manitoba*, Nat. Hist. Soc. Man., p. 36, 1943.

S. myrtillifolia Anderss.—Myrtle-leaved Willow. Frequent on hummocks in spruce swamps. Shrub 1-8 dm high; leaves obtuse or rounded at the apex, crenate.

S. myrtillifolia var. *pseudomyrsinites* (Anderss.) Ball (S. *pseudomyrsinites* Anderss.). —Occasional in edges of swamps and mixed woods northward. Shrub 1-2 m high; leaves thin, lanceolate, acute or acuminate, serrate.

S. myrtilloides L. ssp. *pedicellaris* (Pursh) Anderss. (*S. pedicellaris* Anderss.; *S. pedicellaris* var. *hypoglauca* Fern.).—Bog Willow. Frequent in bogs northward.

S. padophylla Rydb. (*S. pseudomonticola* Ball; *S. barclayi* of Fraser and Russell, not Anderss.).—Cherry-leaf Willow. Frequent along borders of lakes and streams. See Check list of native and naturalized trees of the United States, Agriculture Handbook 41, U. S. Dept. Agr. 392, 1953.

S. pellita Anderss.—Satiny Willow. Frequent along streams in the central eastern part of the area. McKague, Nipawin, Beaver River, Candle Lake, Hudson Bay Junction (UNS, DAO, CAN).

S. pellita forma *psila* Schn. Associated with the typical species but less frequent.

**S. pentandra* L.—Laurel-leaf Willow. Commonly planted as windbreaks in the prairie region.

S. petiolaris J. E. Smith.—Meadow Willow. Common in low meadows, margins of ponds, lakes and streams north to the Churchill River.

S. petiolaris var. *gracilis* Anderss. (*S. gracilis* Anderss.; *S. petiolaris* var. *rosmarinoides* (Anderss.) Schn. and var. *angustifolia* Anderss.).—Associated with the typical species. Differs in having the leaves narrower and more entire. This variety probably represents merely a juvenile stage of leaf development.

S. petiolaris var. *subsericea* Anderss. (*S. subsericea* (Anderss.) Schn.).—Leaves pubescent, especially when young. Associated with the typical species but less common.

S. phyllicifolia L. ssp. **planifolia** (Pursh) Breitung, stat. nov. (*S. planifolia* Pursh,

Fl. Amer. Sept. 2:611, 1814; *S. chlorophylla* Anderss.).—Flat-leaved Willow. Common in swampy places along lakes and streams.

S. phyllicifolia ssp. *planifolia* var. *nelsonii* (Ball) Ball apud Fraser and Russell; *S. nelsonii* Ball; *S. planifolia* var. *nelsonii* (Ball) Ball apud Fraser and Russell).—Associated with the typical species but less frequent.

S. pseudocordata (Anderss.) Rydb. (*S. curtiflora* Anderss.).—Firm-leaf Willow. A Rocky Mountain species frequent along Battle Creek in the Cypress Hills.

S. pyrifolia Anderss. (*S. balsamifera* Barratt.).—Balsam Willow. Occasional around swamps and bogs in the forested region northward. Prince Albert, Prince Albert National Park, Crooked River, Bannock, Bjorkdale, Golburn (UNS, DAO); Lake Athabaska (Raup).

S. scouleriana Barratt (*S. flavescens* Nutt.).—Scouler's Willow. Frequent in the northern forested region to Lake Athabaska (Raup) and in the Cypress Hills (CAN, DAO).

S. serrisima (Bailey) Fern. (*S. erythrocoma* Barratt).—Autumn Willow. Frequent in bogs and swamps. Distinguished from all other willow species by the capsules that mature in late summer and autumn after the first frost.

MYRICACEAE—Bayberry Family

Myrica gale L.—Sweet Gale. Rocky shores and swamps in the Precambrian Shield. Lake Athabaska, Island Lake, Ile a la Crosse (UNS, DAO).

BETULACEAE—Birch Family

Alnus crispa (Ait.) Pursh (incl. var. *elongata* Raup).—Green Alder. Common in sandy pine woods northward.

A. incana (L.) Moench ssp. *rugosa* (Du Roi) R. T. Clausen (*A. rugosa* (Du Roi) Spreng; *A. americana* (Regel) K. Koch).—Speckled Alder. Common in swamps and along streams in the central eastern part of the area.

A. incana ssp. **tenuifolia** (Nutt.) Breitung, stat. nov. (*A. tenuifolia* Nutt., Sylva 1:32, 1842; *A. incana* var. *virescens* S. Wats.).—River Alder. Borders of streams and lakes in the western part of the area. Pike Lake (UNS); Saskatoon, Meadow Lake Forest Reserve (DAO); Prince Albert (CAN).

Betula glandulosa Michx.—Resin Birch. An arctic-alpine species entering our area in the extreme north; Lake Athabaska (Raup).

B. occidentalis Hook. (*B. fontinalis* Sarg.; *B. microphylla* Bunge var. *fontinalis* (Sarg.) M. E. Jones).—River Birch. Common along streams and in sand dune areas, chiefly in the prairie region. Lake Athabaska (Raup).

B. papyrifera Marsh. (*B. alba* L. ssp. *papyrifera* (Marsh) Spach).—Paper Birch. A large tree common on banks of lakes and streams. The report of var. *cordifolia* in Sask. by Fraser and Russell represent var. *humilis*, in part, and typical *B. papyrifera*. Var. *cordifolia*, observed in northern Ontario and adjacent Quebec, has, in addition to cordate leaves, brown to creamy white bark.

B. papyrifera var. *commutata* (Regel) Fern. (*B. occidentalis* of Sarg., not Hook.).—Western Paper Birch. Pine and spruce woods, sand dunes and old beach ridges around Lake Athabaska (Raup). See: Fernald in Rhodora 47:312-17, 1945.

B. papyrifera var. *humilis* (Regel) Fern. & Raup. (*B. alaskana* Sarg., not Lesq.; *B. neoalaskana* Sarg.).—Alaska Paper Birch. Common in the northern forest on sandy soil and dry muskegs.

B. papyrifera var. *subcordata* (Rydb.) Sarg. (*B. subcordata* Rydb.).—Rocky Mountain Birch. A Cordilleran race found occasional in the Cypress Hills (DAO).

B. pumila L. var. *glandulifera* Regel (*B. glandulifera* (Regel) Butler; *B. hallii* Howell; *B. glandulosa* var. *glandulifera* (Regel) Gleason).—Swamp Birch. Common in swamps and bogs through the coniferous forest.

CORYLACEAE—Hazelnut Family

Corylus cornuta Marsh. (*C. rostrata* Ait.; *C. americana* of report from Sask. by Macoun, Cat. Can. Plants, not Walt.).—Beaked Hazelnut. Abundant in woods, especially northward and isolated in the Cypress Hills.

FAGACEAE—Beech Family

Quercus macrocarpa Michx. var. *depressa* (Nutt.) Engelm. (*Q. mandanensis* Rydb.). —Scrub Oak. Moosomin, Oxbow, and along the Pipestone and Qu'Appelle valleys near the Manitoba border (UNS, DAO).

ULMACEAE—Elm Family

Ulmus americana L.—American Elm. Occasional along streams in the forested eastern part of the area. Trossachs, Lumsden, Oxbow, Katepwa, Fort Qu'Appelle, Cumberland House (UNS); Nipawin, Bertwell, Hudson Bay Junction (DAO). Isolated groves have been reported from Outlook and Simpson.

CANNABINACEAE—Hemp Family

Humulus lupulus L.—Common Hops. Frequent in thickets along streams. Katepwa, Leacross, Tisdale, Runciman. Macoun in *Cat. Can. Plants* reports it as common in the valleys of the Assiniboine and Qu'Appelle Rivers.

URTICACEAE—Nettle Family

Laportea canadensis (L.) Gaud.—Wood Nettle. Wooded banks of streams. Gainsborough (DAS, DAO).

Parietaria pensylvanica Muhl. ex Willd. (*P. occidentalis* Rydb.).—American Pellitory. Shaded banks; scarce. Cypress Hills (CAN); Swift Current (DAO); Mortlach (DAO, DASC); Eaglehill Creek near Kelfield (DAS).

Urtica dioica L. var. *procera* (Muhl.) Wedd. (*U. procera* Muhl.; *U. gracilis* Ait.; *U. viridis* Rydb.).—Common Nettle. Frequent on alluvial soil in thickets along streams and lakes.

POLYGONACEAE—Buckwheat Family

Eriogonum cernuum Nutt.—Nodding Umbrella Plant. Dry exposed hills. Abbey (UNS, DASC).

E. flavum Nutt.—Yellow Umbrella Plant. Common on dry prairie and exposed hills.

E. multiceps Nees.—Branched Umbrella Plant. Badlands along the southern border of the area.

**Fagopyrum sagittatum* Gilib. (*F. esculentum* Moench; *Polygonum fagopyrum* L.).—Buckwheat. Persistent in abandoned sandy field at Pre Ste. Marie (UNS, DAO).

**F. tataricum* (L.) Gaertn.—Tartary Buckwheat. Waste place near Silton (DAS).

**Polygonum achoreum* Blake.—Striate Knotweed. Common around dwellings, in vacant lots along roadsides, etc.

P. amphibium L. var. *stipulaceum* (Coleman) Fern. (*P. amphibium* var. *natans* forma *hartwrightii* (A. Gray) Farwell; *Persicaria nebrascensis* Greene).—Frequent in sedge meadows, on gravelly shores and banks or in dried up ponds. Sheaths usually with abruptly spreading herbaceous margins.

P. amphibium var. *stipulaceum* forma *fluitans* (Eaton) Fern. (*P. amphibium* var. *natans* Michx., not Moench; *P. amphibium* ssp. *laevimarginatum* Hultén; *Persicaria fluitans* (Eaton) Greene; *P. psychrophila* Greene).—Water Persicaria. Common in ponds and shallow lakes.

**P. aviculare* L. (*P. caespitosum* Aschers. & Graebn.; *P. ovalifolium* Lehm.).—Doorweed, Yard Knotweed. Common in farm yards, vacant lots, waysides, etc.

**P. aviculare* var. *angustissimum* Meisn. (*P. neglectum* Besser; *P. heterophyllum* Lindm.f.).—Doorweed, Red Knotweed. Frequent in gardens, streets and waste places.

P. aviculare var. *littorale* (Link.) W. D. J. Koch (*P. buxiforme* Small).—Shore Knotweed. Occasional along sandy and alkaline shores. Val Marie, Swift Current, Maple Creek, Saskatoon. *Polygonum aviculare* is a semicosmopolitan, polymorphous, apomictic weedy annual, represented in our area by naturalized and probably indigenous phases. The numerous ecological phases have been variously segregated as forms, varieties, subspecies or even species and the vast series might best be regarded as one exceedingly variable species.

P. cilinode Michx. (*Bilderdykia cilinodis* (Michx.) Greene).—Fringed Black Bindweed. On outcrops of the Precambrian Shield northward. Seven miles SW of Flin Flon (DAS).

P. coccineum Muhl. ex Willd. (*Persicaria coccinea* (Muhl.) Greene; *P. muhlenbergii* (Meisn.) S. Wats.; *P. mesochora* Greene).—Swamp Persicaria. Frequent in marshes. Forms vary with the seasonal depth of water.

P. coccineum var. *pratincola* (Greene) Stanford (forma *terrestre* (Willd.) Stanford; *Persicaria pratincola* Greene).—Meadow Persicaria. Frequent in moist meadows. Regina, Wallwort, Swift Current, Sutherland.

P. coccinea var. *rigidulum* (Sheld.) Stanford (forma *natans* (Wieg.) Stanford; *Persicaria rigidula* (Sheld.) Greene).—Rigid Persicaria. In Water. Moose Jaw (UNS, DAO).

P. confertiflorum Nutt. ex Piper (*P. watsoni* Small, as to description; *nom illegit.*).—Dense-flowered Knotweed. Cypress Hills, Macoun 23577 (CAN).

**P. convolvulus* L. (*Bilderdykia convolvulus* (L.) Dum.).—Wild Buckwheat. Common weed in grain fields and waste places.

P. douglasii Greene.—Douglas' Knotweed. Occasional on dry exposed hillsides. Cypress Hills (UNS, DAO); Mankota, Bengough (UNS); Swift Current (DASC, UNS). Lake Athabaska (Raup); Denare Beach, Amisk Lake (DAS).

P. lapathifolium L. (*Persicaria lapathifolia* (L.) S. F. Gray; *P. incarnata* (Ell.) Small).—Dock-leaved Persicaria. Common on damp shores, in clearings and cultivated fields. Probably both native and introduced.

P. lapathifolium var. *salicifolium* Sibth. (*P. lapathifolium* var. *incanum* (Willd.) W. D. J. Koch).—Willow-leaved Persicaria. Frequent along shores.

P. prolificum (Small) B. L. Robins. (*P. ramosissimum* var. *prolificum*, *P. rubescens* Small).—Proliferous Knotweed. Occasional on low prairie. Swift Current, Beverly, Govenlock, Saskatoon, Patience Lake (DASC, UNS).

P. punctatum Ell. var. *leptostachyon* Meisn.—Water Smartweed. Marshy shores of lakes northward. Amisk Lake (DAS); Ile a la Crosse (DAO, as *P. hydropiper*).

P. ramosissimum Michx. (*P. exsertum* Small).—Bushy Knotweed. Occasional in saline soil. Saskatoon, Swift Current, Tisdale, Watrous, Kelstairs, Amisk Lake. Bicknell in Bull. Torrey Bot. Club 36:450, 1900 states "I am unable to see that *P. exsertum* is anything more than a semi-viviparous state of *Polygonum ramosissimum* Michx." Observations indicate that the early flowering specimens have normal included achenes, whereas plants collected in autumn bear predominantly exserted achenes.

**P. scabrum* Moench (*Persicaria incana* (Schmidt) S. F. Gray; *P. tomentosa* (Schrank) Bickn.; *P. pennsylvanica* of Fraser and Russell, ed 3, not L.).—Hairy Persicaria. Lake shores and cultivated fields. Beauval, Wasaca (DAS).

P. viviparum L. (*Bistorta vivipara* (L.) S. F. Gray).—Alpine Persicaria. Occasional in muskegs and damp shores of Lake Athabaska (Raup).

**Rumex acetosa* L.—Sour Dock. Escaped along roadsides. Rosthern, Warman (DAS).

**R. acetosella* L.—Sheep Sorrel. Cypress Hills, McKague (DAO); Holbein, Murraydale, Prince Albert, Scott, St. Louis, Waldheim (UNS).

**R. crispus* L.—Curled Dock. Occasional along roadsides and in waste places. McKague (UNS, DAO).

**R. domesticus* Hartm. (*R. altissimus* of Fraser and Russell, ed 2, not Wood).—Field Dock. Upland grain fields and slough margins. Wymark (UNS); Davidson (DAS, DASC). According to A. C. Budd in The Blue Jay 12(4):5, 1954, it is rapidly spreading and becoming abundant "on the Regina plains, north to Davidson and all through the southwestern part of the province."

R. maritimus L. var. *fueginus* (Phil.) Dusén (*R. fueginus* Phil.; *R. persicarioides* of auth., not L.).—Golden Dock. Common on sandy shores.

R. mexicanus Meisn. var. *triangulivalvis* (Danser) Lepage (*R. triangulivalvis* (Danser) Rech f.).—Narrow-leaved Dock. Common in damp soil; widely distributed.

**R. obtusifolius* L.—Blunt-leaved Dock. Wet roadsides and ditches. Weyburn (DAO).

R. occidentalis S. Wats. var. *fenestratus* (Greene) Lepage (*R. fenestratus* Greene).—Western Dock. Frequent in wet sedge meadows. McKague, Sutherland, Swift Current, Cypress Hills.

R. orbiculatus A. Gray.—Water Dock. Along lake shores northward. Amisk Lake, Sulphide Lake (DAS, DAO); Ile a la Cross, Meadow Lake, Lac la Ronge (DAO).

R. venosus Pursh.—Sand Dock, Wild Begonia. Common on sandy banks in the prairie region.

CHENOPODIACEAE—Goosefoot Family

Atriplex argentea Nutt.—Silvery Saltbush. Frequent on alkaline flats in the prairie region. Forward, Maple Creek, Piapot, Mortlach.

A. dioica (Nutt.) Macbr. (*Endolepis dioica* (Nutt.) Standl.; *E. suckleyi* Torr.).—Rillscale. Dry hills. Elbow of the South Saskatchewan River (CAN); Bracken, Val Marie (UNS).

**A. hortensis* L. (*A. nitens* Schk.).—Garden Orache. A garden herb frequently escaped in waste places, roadsides, etc.

**A. hortensis* var. *atro-sanguinea* Hort.—A crimson-leaved ornamental occasionally escaped.

A. nuttallii S. Wats.—Nuttall's Atriplex. Common on arid plains and badlands.

A. patula L.—Spreading Saltbush. Occasional on alkaline shores of ponds and lakes.

A. patula var. *hastata* (L.) A. Gray (ssp. *hastata* (L.) Hall & Clements; *A. carnosa* A. Nels.).—Halbered-leaved Saltbush. Common in saline meadows.

**Axyris amaranthoides* L.—Russian Pigweed. A common weed in waste places.

**Bassia hyssopifolia* (Pall.) Kuntze (*Echinopsilon hyssopifolium* (Pall.) Moq.).—Five-hook Bassia. Alkaline soil along railway tracks at Swift Current (DASC, CAN). See: Budd in The Blue Jay 10(4):24, 1952.

**Chenopodium album* L. (*C. paganum* Reichnb.).—Lamb's Quarters, Pigweed. A common weed in fields, gardens and waste places.

**C. album* forma *lanceolatum* (Muhl.) Aellen (*C. lanceolatum* Muhl.).—Lance-leaved Goosefoot. Roadsides and waste places. Moose Jaw, Kisby, Mortlach, Trossachs (UNS).

C. berlandieri Moq. var. *farinosum* (Ludwig) Aellen (*C. dacoticum* Standley).—Stinking Goosefoot. Dry, slightly saline prairie, Elbow (DASC, DAO, UNS).

C. capitatum (L.) Aschers. (*Blitum capitatum* L.)—Strawberry Blite. Frequent in rich moist woods.

C. fremontii S. Wats.—Fremont's Goosefoot. Damp thickets on stream banks. Swift Current, Saskatoon, Cypress Hills, Mortlach.

C. glaucum L. ssp. *salinum* (Standl.) Aellen (*C. salinum* Standl.; *C. glaucum* var. *salinum* (Standl.) Boivin).—Oak-leaved Goosefoot. Frequent in alkaline soil.

C. hybridum L. var. *gigantospermum* (Aellen) Rouleau (*C. gigantospermum* Aellen).—Maple-leaved Goosefoot. Common in clearings, thickets and waste places.

C. leptophyllum Nutt. ex Moq.—Narrow-leaved Goosefoot. Occasional on sandy soil. Mortlach, Swift Current, Webb, Cypress Hills.

**C. polyspermum* L.—Many-seeded Goosefoot. Weed in garden at Wallwort (DAO, UNS).

C. pratericola Rydb. ssp. *desiccatum* (A. Nels.) Aellen (*A. desiccatum* A. Nels.; *C. oblongifolium* (S. Wats.) Rydb.).—Arid Goosefoot. Dry plains. Merryflat south of the Cypress Hills (DAO, DASC). See: Aellen & Just in "Key and Synopsis of the American species of the genus Chenopodium," Amer. Midl. Nat. 30(1):47-76, 1943.

C. rubrum L. (*C. humile* of Sask. reports, not Hook.; *C. ambrosioides* of Fraser and Russell ed 3, not L.).—Red Goosefoot. Frequent in borders of saline marshes and lakes. Meadow Lake, Rush Lake, Wallwort (UNS, DAO); Cypress Hills, collected by Macoun, Aug. 25, 1880 (CAN, as var. *humile*).

Corispermum hyssopifolium L. (*C. marginale* Rydb.).—Winged Bug-seed. Cultivated fields, railway tracks and sandy prairie. Appearing largely introduced and perhaps is partly indigenous. It is unclear to what extent this and the following two species are introduced into our area, perhaps also partly adventive from native habitats into cultivated fields. Perhaps they have been entirely introduced appearing indigenous on sand dunes similar to that of *Salsola kali* var. *tenuifolia*, thought to be native by A. Nelson when he described it as *S. pestifer*.

C. nitidum Kit. ex Schult.—Neat Bug-seed. Sandy prairie. Pike Lake, J. L. Bolton, Aug. 24, 1945 (DAS). Distinguished from our other species in being more slender with

laxer inflorescence and much shorter bracts (2-5 mm long), scarcely imbricate exposing the axis; seeds 2-3 mm long, narrowly winged.

C. orientale Lam. var. *emarginatum* (Rydb.) Macbr. (*C. villosum* Rydb.).—Wingless Bug-seed. On sandhills and dunes in the southwestern part of our area. Webb (DAS); Beverly, Cadillac (UNS, DAO). Seeds wingless. Owing to the more restricted distribution it probably is indigenous.

Cyclocoma atriplicifolium (Spreng.) Coult.—Winged Pigweed. Sandy soil. Baildon (UNS).

Eurotia lanata (Pursh) Moq.—Winter Fat. Common on dry prairie.

**Kochia scoparia* (L.) Schrader (*K. trichophylla* Stapf.; *Chenopodium scoparia* L.). —Summer Cypress. Commonly escaped in waste places. Swift Current, Saskatoon.

Monolepis nuttalliana (Schult. ex Roem. & Schult.) Greene.—Spear-leaved Goosefoot. Common on saline prairie and a weed in cultivated fields and in waste places.

Salicornia europaea L. ssp. **rubra** (A. Nels.) Breitung, comb. nov. (*S. rubra* A. Nels., Bull. Torrey Club 26:122, 1899).—Samphire. Common in borders of alkaline sloughs and lakes.

**Salsola kali* L. var. *tenuifolia* Tausch (*S. pestifer* A. Nels.).—Russian Thistle. A common weed in cultivated fields on sandy soil in the prairie region.

Sarcobatus vermiculatus (Hook.) Torr.—Greaswood. Occasional on alkaline prairie. Val Marie, Maple Creek, Kelstairs, Beverly.

Suaeda depressa (Pursh) S. Wats. (*Dondia depressa* (Pursh) Britt.).—Western Blite. Frequent in borders of saline sloughs and lakes.

S. depressa var. *erecta* S. Wats. (*D. erecta* (S. Wats.) A. Nels.).—Erect Sea Blite. Associated with the typical species and perhaps merely a phase of it.

Suckleya suckleyana (Torr.) Rydb. (*Obione suckleyana* Torr.; *S. petiolaris* A. Gray). Suckleya. Stream banks. Moose Jaw (UNS); Tuxford (CAN).

AMARANTHACEAE—Amaranth Family

**Amaranthus albus* L. (*A. graecizans* of various auth., not L.).—Tumble Weed. Common in waste ground, gardens, roadsides, etc. Probably adventive into our area.

**A. graecizans* L. (*A. blitoides* S. Wats.).—Prostrate Amaranth. Common weed in gardens, lawns and waste places. Adventive from the south and west.

**A. retroflexus* L.—Red-root Pigweed. Common weed in gardens and waste places.

NYCTAGINACEAE—Four-o'clock Family

Mirabilis hirsuta (Pursh) MacM. (*Oxybaphus hirsuta* (Pursh) Sweet; *Allionia hirsuta* Pursh; *A. pilosa* (Nutt.) Rydb.; *A. linearis* of reports from Sask. in Macoun, Cat. Can. Plants, not Pursh).—Hairy Umbrella-wort. Frequent in sandy soil in the prairie region. Beaver Creek, Antelope, Oxbow, Qu'Appelle, Saskatoon, Sutherland, Mortlach (UNS, DASC); Cypress Hills (CAN).

A. nyctaginea (Michx.) MacM. (*O. nyctagineus* (Michx.) Sweet; *A. nyctaginea* Michx.; *A. ovata* Pursh).—Heart-leaved Umbrella-wort. In dry soil and railway embankments. Estevan, Swift Current, Mortlach (UNS, DAO, DASC).

PORTULACACEAE—Purslane Family

Claytonia lanceolata Pursh (*C. caroliniana* of Sask. reports, not Michx.).—Lance-leaved Spring Beauty. Meadows and aspen woods in the Cypress Hills (UNS, DASC, DAO).

C. linearis Dougl. (*Moniastrum lineare* (Dougl.) Rydb.; *Montia linearis* (Dougl.) Greene).—Linear-leaved Spring Beauty. Occasional in moist thickets and open hillsides in the Cypress Hills (UNS, DAO, DASC).

**Portulaca oleracea* L.—Purslane. Common weed in gardens and waste places.

CARYOPHYLLACEAE—Pink Family

**Agrostemma githago* L.—Purple Cockle. Occasional in grain fields.

Arenaria congesta Nutt. ex Torr. & Gray var. *lithophila* (Rydb.) Maguire (*A. subcongesta* (S. Wats.) Rydb. var. *lithophila* Rydb.; *A. lithophila* (Rydb.) Rydb.; *A. con-*

gesta var. *expansa* Maguire).—Rocky-ground Sandwort. Common on grassy slopes of the Cypress Hills (CAN, DAS, DASC, UNS).

A. lateriflora L. (*Moehringia lateriflora* (L.) Fenzl.).—Grove Sandwort. Common in aspen groves.

A. macrophylla Hook. (*M. macrophylla* (Hook.) Torr.).—Large-leaved Sandwort. Rich woods at Lake Athabaska (Raup).

A. rubella (Wahlenb.) J. E. Smith (*A. verna* L. var. *rubella* (Wahlenb.) S. Wats.; var. *propinqua* (Richards.) Fern.; var. *pubescens* (Cham. & Schl.) Fern.; *Alsinopsis propinqua* (Richards.) Rydb.; *Minuartia rubella* (Wahlenb.) Graebn.).—Boreal Sandwort. Exposed grassy slopes on the Cypress Hills (UNS, DAO); Lake Athabaska (Raup).

**A. serpyllifolia* L.—Thyme-leaved Sandwort. Edge of cultivated field near Tisdale (UNS, DAO).

A. stricta (Sw.) Hiern ssp. *dawsonensis* (Britt.) Maguire (*A. dawsonensis* Britt.; *Alsinopsis dawsonensis* (Britt.) Rydb.; *Sabulina dawsonensis* (Britt.) Rydb.).—Rock Sandwort. Gravelly bank of the Barrier River at McKague (UNS, DAO); Lake Athabaska (Raup).

Cerastium arvense L. (*C. campestre* Greene).—Field Chickweed. Common on open prairie and sandy ridges.

C. beeringianum Cham. & Schl.—Beering's Chickweed. Rocky crevices and damp shores of Lake Athabaska (Raup).

C. nutans Raf.—Long-stalked Chickweed. Frequent in edge of moist woods.

**C. vulgatum* L.—Common Chickweed. Weed in lawn at Mortlach (DAO).

**Gypsophila paniculata* L.—Baby's Breath. Occasional escape from cultivation.

**Lychnis alba* Mill. (Melandrium album (Mill.) Garcke). White Campion. Weed in cultivated fields. Saskatoon (UNS).

L. drummondii (Hook.) S. Wats. (*Silene drummondii* Hook., *Wahlbergella drummondii* (Hook.) Rydb.; *Melandrium drummondii* (Hook.) A. E. Porsild).—Drummond's Cockle. Widespread on prairie but not common.

Paronychia sessilflora Nutt. (*P. depressa* of Fraser and Russell, ed 2, not Nutt.).—Low Whitlow-wort. Dry hills on prairie. Sutherland, Cypress Hills, Estevan, Saskatchewan Landing (UNS); Swift Current, Mortlach (DAO).

Sagina nodosa (L.) Fenzl. (*Spergula nodosa* L.).—Knotty Pearlwort. Rock crevices and sandy shores of Lake Athabaska (Raup); Amisk Lake (DAS).

**Saponaria vaccaria* L. (*Vaccaria vulgaris* Host).—Cow Cockle. Occasional escape from gardens along roadsides and in grain fields.

**Scleranthus annuus* L.—Knawel. Weed in waste place at Wolseley (UNS); Waseca (DAS).

Silene antirrhina L.—Sleepy Catchfly. Sandy and rocky hillsides on shore of Lake Athabaska (Raup); Denare Beach, Flin Flon (DAS).

**S. cserei* Baumg. (*S. fabaria* of Rydb. Fl. Pr. Pl. Cent. N. Amer. 324, not Sibth. & Sm.).—Smooth Catchfly. Weed along railway embankments, roadsides and waste places. Swift Current (DASC). Cypress Hills, Mortlach (DAO).

**S. cucubulus* Wibel (*S. vulgaris* (Moench) Garcke; *S. latifolia* (Mill.) Britt. & Rendle; *S. inflata* Sm.).—Bladder Campion. Fields, roadsides and railway embankments. Wallwort, Swift Current, Indian Head, Odessa, Quill Lake.

S. menziesii Hook.—Menzies' Catchfly. Thickets on stream banks. Cypress Hills, Emma Lake, Waskesiu Lake, Candle Lake (UNS; DAO).

**S. noctiflora* L.—Night-flowering Catchfly. A common weed in fields and along roadsides.

Spergula marina (L.) Griseb. var. *leiosperma* (Kindb.) Gürke (*S. salina* J. & G. Presl; *S. sparsifolia* (Greene) A. Nels.).—Salt-marsh Sand Spurry. Occasional on saline flats. Dana, Kelstairs, Scott, Patience Lake, Wakaw.

Stellaria arenicola Raup.—Sand Chickweed. Among shifting sand dunes at Lake Athabaska (Raup). Perhaps not distinct from *S. longipes*.

S. calycantha (Ledeb.) Bong. (*S. borealis* Bigel.; *S. alpestris* Fries; *Alsine borealis* (Bigel.) Britt.).—Northern Chickweed. Occasional in moist shaded places. Crooked River, Wallwort, Tisdale, Cypress Hills, Pike Lake, Waskesiu Lake.

S. crassifolia Ehrh. (*A. crassifolia* (Ehrh.) Britt.).—Fleshy Chickweed. Occasional

on damp shaded banks. McKague, Wallwort, Emma Lake, Hudson Bay Junction, Pike Lake, Sutherland.

**S. graminea* L. (*A. graminea* (L.) Britt.).—Lesser Chickweed. Waste places and wet meadows. Waskesiu Lake (UNS).

S. longifolia Muhl. ex Willd. (*A. longifolia* (Muhl.) Britt.).—Long-leaved Chickweed. Common in damp meadows, thickets and shores.

S. longipes Goldie. (*A. longipes* (Goldie) Cov.; *S. stricta* Richards.).—Long-stalked Chickweed. Common on moist prairie, dry hillsides and sandy pine woods.

**S. media* (L.) Cyrill. (*A. media* L.).—Common Chickweed. Noxious weed in gardens and waste places.

CERATOPHYLLACEAE—Hornwort Family

Ceratophyllum demersum L.—Hornwort. Ponds and slow streams. Heart Lakes, Buffalo Lake, Echo Lake, Big River, Mortlach.

NYMPHACEAE—Water Lily Family

Nuphar variegatum Engelm. (*N. advena* (Ait.) Ait.f. ssp. *variegatum* (Engelm.) R. T. Clausen; *Nymphaea advena* Ait. var. *variegata* (Engelm.) Fern.; *N. variegatus* (Engelm.) G. S. Mill.; *Nymphozanthus variegatus* (Engelm.) Fern.).—Yellow Water Lily. Common in lakes and sluggish streams northward.

Nymphaea tetragona Georgi ssp. *leibergii* (Morong) Porsild (*N. leibergii* Morong; *Castalia leibergii* Morong).—Small White Water Lily. In Saskatchewan River near Cumberland Lake (UNS).

RANUNCULACEAE—Buttercup Family

Actaea rubra (Ait.) Willd. (*A. spicata* L. var. *rubra* Ait.).—Red Baneberry. Common in rich woods.

A. rubra forma *neglecta* (Gillman) Robins. Associated with the typical species and usually equally common. This form with ivory-white berries has been confused in Rydberg's manuals with the eastern thick-pedicelled *A. alba* (L.) Mill. (*A. pachypoda* Ell.; *A. eburnea* Rydb.).—See Fernald in Rhodora 42:260-264, 1940; Gleason in Rhodora 46:146-148, 1944.

Anemone canadensis L.—Wind-flower or Meadow Anemone. Common in low woods and low meadows. A specimen from Crestwynd southwest of Regina reported as *A. richardsonii* by Fraser and Russell, ed 3, has proven to be *A. canadensis*.

A. cylindrica A. Gray.—Long-fruited or Candle Anemone. Common on moist prairie.

A. multifida Poir. var. *hudsoniana* (Richards.) DC. (*A. hudsoniana* Richards.).—Hudsonian Anemone. Common on prairie and in open woods. Sepals 5-10 mm long, purplish.

A. multifida var. *richardsiana* Fern. (*A. globosa* of Sask. reports, not Nutt.).—Richard's Anemone. Grassy slopes and open forest on the Cypress Hills. Sepals 11-17 mm long, purplish or milky-white in forma *leucantha* Fern. *Anemone multifida* var. *globosa* (Nutt.) Gray [*A. lithophila* Rydb.; *A. tetonensis* Porter] is an alpine race of high mountains in western North America, having sepals 6-12 mm long, usually creamy-white within and tinged with blue on the outside.

A. patens L. var. *wolfgangiana* (Bess.) Koch (var. *nuttalliana* A. Gray; *Pulsatilla ludoviciana* (Nutt.) Heller; *P. hirsutissima* Britt.).—Crocus Anemone. Abundant on prairie and sandy ridges northward.

A. quinquefolia L. var. *interior* Fern.—Wood Anemone. In aspen woods near Somme (DASC). See A. C. Budd in The Blue Jay 12(2):15, 1954.

A. richardsonii Hook.—Richardson's Anemone. North shore of Lake Athabaska (CAN).

A. virginiana L. (*A. riparia* Fern.).—Tall Anemone. Occasional in woods. Yorkton (UNS); Carlyle Lake, Elbourne, Qu'Appelle Valley, Bjorkdale, McKague, Nipawin (DAO).

Aquilegia brevistyla Hook.—Small-flowered Columbine. Occasional in open woods and river banks. Le Cole Falls, McKague, Montreal Lake, Prince Albert, Prince Albert National Park, Torch River (UNS); Nipawin (DAO).

A. canadensis L. (*A. latiuscula* Greene).—Wild Columbine. Crooked Lake in the Qu'Appelle Valley; Thunderhill north of Arran; Canora (DAO).

Caltha natans Pall.—Floating Marsh-marigold. Windrum Lake (CAN); Amisk Lake (DAS).

C. palustris L.—Marsh Marigold. Common in marshes and springy places northward.

Clematis ligusticifolia Nutt. ex Torr. & Gray.—Western Virgin's Bower. Climbing over bushes in valleys of the southwest. Great Sand Hills, Cypress Hills, Piapot, Pike Lake, Saskatchewan Landing, Mortlach.

C. verticellaris DC. var. *columbiana* (Nutt.) A. Gray (*Atragene columbiana* Nutt.). —Western Purple Virgin's Bower. Wooded slopes of the Cypress Hills (DAO, UNS).

Coptis trifolia (L.) Salisb. ssp. *groenlandica* (Oeder) Hultén (*C. trifolia* var. *groenlandica* (Oeder) Fassett; *C. groenlandica* (Oeder) Fern.).—Gold-thread. Spruce muskegs northward. Amisk Lake, Nipawin (DAS); Lake Athabaska (Raup).

Delphinium bicolor Nutt. (*D. virescens* of report from Sask. by Macoun, Cat. Can. Plants, not Nutt.).—Prairie Larkspur. Occasional on open grassy slopes. Cypress Hills, Piapot, Robsart, Wood Mtn., Wyatt.

D. glaucum S. Wats. (*D. scopulorum* A. Gray var. *glaucum* (S. Wats.) A. Gray; *D. brownii, D. canmorense* Rydb.).—Tall Larkspur. Occasional in open woods and meadows in the mixed wood section in central western Saskatchewan. Mudi Lake (UNS); Meadow Lake, Loon Lake (DAO); Prince Albert (DASC).

Myosurus minimus L. (*M. lepturus* (A. Gray) Howell).—Least Mouse-tail. Occasional in mud, shallow water and alkaline soil. Cypress Hills, Chaplin, Fife Lake, Hitchcock, Saskatoon (UNS); Sutherland (DAS); Mortlach (DAO); Maple Creek (DAS, CAN, GH); Wood Mtn. (CAN, GH).

M. minimus ssp. *montanus* Campbell. (*M. aristatus* of Sask. reports, not Benth.).—Mountain Mouse-tail. Cypress Hills (UNS, DAS, as *M. aristatus*); Swift Current (UNS, DAS, DASC, as *M. lepturus*); Wood Mtn. (CAN, GH, distributed as *M. aristatus*). See: Campbell in El Aliso 2(4):389-403, 1952.

Ranunculus abortivus L. (*R. micranthus* of western reports, not Nutt.).—Smooth-leaved Buttercup. Widespread in woods but never common.

**R. acris* L. (*R. steveni* Andrz.; *R. montanensis* of Fraser and Russell, ed 2, not Rydb.).—Tall Buttercup. Occasional along roadsides. Tisdale, Crooked River, Scott, Swift Current, Wadena, Saskatoon (UNS); Cypress Hills, Prince Albert (DAO).

R. aquatilis L. var. *capillaceus* (Thuill.) DC. (*R. trichophyllus* Chaix; *Batrachium trichophyllus* (Chaix) F. Schultz).—White Water Buttercup. In brook by power house in Cypress Hills Park(DASC, DAO). According to Benson, Amer. Midl. Nat. 40:239, 1948, *Ranunculus divaricatus, R. circinatus, R. drouetii,* and *R. flaccidus* are old European names used in America.

R. aquatilis var. *longirostris* (Godron) Lawson (*R. longirostris* Godron; *Batrachium longirostre* (Godron) F. Schultz).—Shallow ponds and slow-moving streams. Battle Creek at Fort Walsh in the Cypress Hills (DAO); Crane Lake (CAN).

R. aquatilis var. **subrigidus** (W. Drew) Breitung, trans. nov. (*R. subrigidus* Drew, Rhodora 38:39, 1936; *R. circinatus* Sibth. var *subrigidus* (Drew) Benson; *R. amphibius* James).—Widespread and common in ponds and shallow lakes.

R. cardiophyllus Hook. (*R. pedatifidus* var. *cardiophyllus* (Hook.) Britt.).—Heart-leaved Buttercup. Occasional on moist prairie in the SW part of the area. Cypress Hills (CAN, DAO, DASC).

R. cymbalaria Pursh (*Halerpestes cymbalaria* (Pursh) Greene).—Alkali Buttercup. Common on shores of alkaline sloughs.

R. flamula L. var. *ovalis* (Bigel.) Benson (*R. reptans* of auth., not L.).—Creeping Buttercup. Scarce in damp meadows. Saskatoon (UNS); Cypress Hills (DAO).

R. glaberrimus Hook. var. *ellipticus* (Greene) Greene (*R. ellipticus* Greene; *R. waldronii* Lunell; *R. buddii* Boivin; *R. buddii* f. *monochlamydeus* Boivin).—Sagebrush Buttercup. Occasional on moist prairie in the southern part of our area. Bienfait, Consul, Cadillac, Swift Current (UNS, DAO, DASC); Mortlach (DAS).

R. gmelini DC. var. *hookeri* (D. Don) Benson (*R. purshii* Richards.; *R. delphinifolius* of Fraser and Russell, not Torr.).—Hooker's Buttercup. Occasional in ponds and on muddy shores. McKague, Beaver Creek, Fenton, Round Lake, Saskatoon (UNS); Lake Athabaska (Raup).

R. inamoenus Greene (*R. inamoenus* var. *elatior* Boivin).—Graceful Buttercup. Scarce on moist grassy slopes. Cypress Hills (UNS, DAO, DASC).

R. lapponicus L. (*Coptidium lapponicum* (L.) Gand.).—Lapland Buttercup. In black spruce swamps northward. McKague, Prince Albert, Waskesiu Lake, Langham (UNS); Lake Athabaska (Raup).

R. macounii Britt.—Macoun's Buttercup. Common in damp meadows.

R. pedatifidus J. E. Smith var. *affinis* (R. Br.) Benson (*R. affinis* R. Br.; *R. apetalus* Farr, not D. Don; *R. pedatifidus* var. *cardiophyllus* f. *apetalus* Boivin).—Northern Buttercup. Moist prairie. Luseland, Swift Current, Saskatoon, Cadillac (UNS, DASC); Scott, Plunkett, Tessier (DAS); Dinsmore, Lloydminster (DAO). See: Benson in Amer. Midl. Nat. 52:355, 1954.

R. pensylvanicus L.f.—Bristly Buttercup. Occasional in damp sedge meadows and alluvial shores. Crooked River, Hudson Bay Junction, Bjorkdale, McKague, Pike Lake, Waskesiu Lake.

R. rhomboideus Goldie (*R. ovalis* of auth., not Raf.).—Prairie Buttercup. Common on moist prairie.

R. sceleratus L.—Celery-leaved Buttercup. Common around springs and sloughs.

Thalictrum dasycarpum Fisch. & Lall. ex Fisch., Mey & Lall. (*T. purpurascens* L. var. *dasycarpum* (Fisch. & Lall.) Trel.; *T. hypoglaucum* Rydb.; *T. purpurascens* of western reports, not L.).—Tall Meadow Rue. Frequent in damp thickets.

T. occidentale A. Gray (*T. megacarpum* Torr.; *T. columbianum* Rydb.; *T. breitungii* Boivin).—Western Meadow Rue. Moist woods in the Cypress Hills (UNS, DAO).

T. sparsiflorum Turcz. ex Fisch., Mey. & Lall. (*T. richardsonii* A. Gray).—Few-flowered Meadow Rue. Along springs in rich woods northward. Waskesiu Lake (DAS); Meadow Lake (DAO).

T. venulosum Trel. (*T. campestre, T. lunellii* Greene; *T. turneri* Boivin; *T. dioicum* of western reports, not L.).—Veiny-leaved Meadow Rue. Frequent in moist meadows and open woods. Muenster, McKague, Dana, Luseland (UNS); Nipawin, Candle Lake, Cypress Hills, Swift Current (DAO); Crane Lake, Tramping Lake, Prince Albert (CAN, GH).

PAPAVERACEAE—Poppy Family

Argemone intermedia Sweet.—White Prickly Poppy. A collection from Prince about 15 miles north of Battleford has been assigned to this species (UNS). Probably escaped from flower garden. It may prove to be *A. platyceras* Link & Otto, a species more common in cultivation.

FUMARIACEAE—Fumitory Family

Corydalis aurea Willd. (*Capnoides aurem* (Willd.) Kuntze).—Golden Corydalis. Common in damp woods.

C. sempervirens (L.) Pers. (*Capnoides sempervirens* (L.) Borkh.).—Pink Corydalis. Frequent in sandy pine woods and granite outcrops northward.

Fumaria officinalis L.—Fumitory. Cultivated and escaped at Lewvan (DAS).

CRUCIFERAE (Brassicaceae)—Mustard Family

Alyssum desertorum Stapf. (*A. alyssoides of Sask.* reports, not L.).—Yellow Alyssum. Indian Head (UNS); Mortlach, J. H. Hudson in Can. Field-Nat. 65:204, 1951. Pods glabrous and more or less shiny.

Arabis arenicola (Richards.) Gelert.—Arctic Rock-cress. North shore of Lake Athabaska (Raup).

A. divaricarpa A. Nels. (*A. brachycarpa* Amer. auth., not Rupr.; *A. confinis* S. Wats.; *A. bourgovii* Rydb.; *A. dacotica* Greene; *A. lyallii* of report from Sask. by Macoun, Cat. Can. Plants, not S. Wats.).—Purple Rock-cress. Frequent on dry hills and prairie. Lake Athabaska (Raup); Saskatoon, Indian Head, Meadow Lake (UNS, DAO); Cypress Hills (CAN, DAO); Clear Water River, Old Wives Creek and west of the Touchwood Hills (CAN); Prince Albert (CAN, as var. *stenocarpa,* a narrow-podded form).

A. drummondii A. Gray (*A. oxyphylla, A. albertina* Greene).—Drummond's Rock-

cress. Occasional on dry rocky or gravelly exposed banks. McKague, Wallwort (UNS, DAO); Saskatoon, Swift Current (UNS); Cypress Hills (CAN). Specimens without developed pods are difficult to separate from *A. divaricarpa*. Fraser and Russell, *loc. cit.* 30, state: "This species is very similar to A. divaricarpa and some of the collections assigned here may belong to that species."

**A. glabra* (L.) Bernh. (*Turritis glabra* L.)—Tower Mustard. Abandoned fields and waste places. Wallwort, Bjorkdale, Saskatoon, Cypress Hills, Meota.

A. hirsuta (L.) Scop. var. *pycnocarpa* (Hopkins) Rollins (ssp. *pycnocarpa* (Hopkins) Hultén; *A. ovata* (Pursh) Poir.).—Hirsute Rock-cress. Occasional in open woods and prairie. Swift Current, McKague, Wilkie, Dafoe, Lanigan, Humboldt.

A. holboellii Hornem. var. *pinetorum* (Tidestrom) Rollins (*A. pinetorum* Tidestrom; *A. pendulocarpa* of reports from Sask. by Hopkins, Rhodora 39:185, 1937, not A. Nels.).—Pink Rock-cress. Occasional on prairie and sparsely wooded sections in the southwestern part of the area. Twelve-mile Lake near Wood Mtn., Pheasant Plain (CAN).

A. holboellii var. *retrofracta* (Graham) Rydb. (*A. retrofracta* Graham; *A. retrofracta* var. *collinsii* (Fern.) Rollins).—Reflexed Rock-cress. Common on prairie and hillsides north to Lake Athabaska.

A. lyrata L. var. *kamchatica* Fisch. ex DC. (ssp. *kamchatica* (Fisch.) Hultén; var. *glabra* (DC.) Hopkins).—Lyre-leaved Rock-cress. Sandy pine woods northward. Hudson Bay Junction, Bjorkdale, Prince Albert (UNS, DAO); Lake Athabaska (Raup). Rollins considers our western form a weak variety. For "A Monographic Study of Arabis in Western North America" see Rollins in Rhodora 43:289-325, 348-411, 425-481, 1941.

**Armoracia rusticana* Gaertn.—Horse Radish. Escaped from cultivation in farmyards and along roadsides.

Barbarea orthoceras Ledeb. (*B. americana* Rydb.; *B. stricta* of Amer. auth., not Andrz.; *Campe orthoceras* (Ledeb.) Heller; *C. americana* Rydb.).—Erect-fruited Winter Cress. Sandy and rocky shores of lakes and streams. Cypress Hills (UNS, DAO); Amisk Lake (DAS); Lake Athabaska (Raup).

**Berteroa incana* (L.) DC.—Hoary Alyssum. Waste places. Balgonie (UNS); Mortlach (DAO).

**Brassica hirta* Moench (*Sinapis alba* L.).—Charlock. Weed in garden at Saskatoon (DAS).

**B. juncea* (L.) Cosson.—Indian Mustard. Common weed in cultivated fields, waste places and along roadsides.

**B. kaber* (DC.) L. C. Wheeler (*B. arvensis* (L.) Rabenh., not L.; *Sinapis arvensis* L.).—Wild Mustard. Common in grain fields and waste places.

**Camelina microcarpa* Andrz.—Small-seeded False Flax. Abundant in cultivated fields and waste places except in the southwest corner.

**C. parodii* Ibarra & La Porte in Revista Argentina Agronomia 14:104, 1947. (*C. dentata* of American authors, not Pers.).—Flat-seeded False Flax. Delisle, Swift Current (UNS). See: M. R. Murley in "Seed of the Cruciferae of Northeastern North America" Amer Midl. Nat. 46(1):1-81, 1951.

**C. sativa* (L.) Crantz.—Large-seeded False Flax. In grain fields. Bladworth, Indian Head (DAO). Very similar to C. microcarpa from which it is distinguished by having glabrous stems and slightly larger seeds.

Cardamine pensylvanica Muhl. ex Willd.—Pennsylvania Bitter Cress. Along brooks. McKague, Cypress Hills (UNS, DAO).

C. pratensis L. ssp. *palustris* (Wimm. & Grab.) R. T. Clausen (*C. pratensis* var. *palustris* Wimm. & Grab.).—Bitter Cress. Occasional in marshes. Pike Lake, McKague, Prince Albert National Park, Sylvania.

**Cardaria draba* (L.) Desv. (*Lepidium draba* L.).—Heart-podded Hoary Cress. Occasional in cultivated fields, gardens and roadsides. Indian Head (UNS).

**C. draba* var. *repens* (Schrenck) O. E. Schulz.—Lens-podded Hoary Cress. Cultivated fields, etc. Landis, Saskatoon, Trynor, Wolseley.

**C. pubescens* (C. A. Mey.) Rollins var. *elongata* Rollins (*Hymenophysa pubescens* of Amer. auth., not C. A. Mey.).—Globe-podded Hoary Cress. Cultivated fields and roadsides. Kelliher, Scott, Swift Current, Sutherland, Wilkie.

**Conringia orientalis* (L.) Dum.—Hare's Ear Mustard. Common in cultivated fields and along roadsides.

Descurainia pinnata (Walt.) Britt. ssp. *brachycarpa* (Richards.) Detling (*D. pinnata* var. *brachycarpa* (Richards.) Fern.; *Sisymbrium cannescens* Nutt. var. *brachycarpa* (Richards.) S. Wats.; *Sophia brachycarpa* (Richards.) Rydb.; *S. hartwegianum* of auth., not Fourn.).—Short-fruited Tansy Mustard. Dry eroded banks and sandy soil. Elbow, Lanigan, Saskatoon, Swift Current. Specimens from Swift Current and Val Marie, cited by Fraser and Russell as *Sophia filipes* likely to belong to the above ssp. *brachycarpa* or possibly to ssp. *intermedia*, which according to Detling occurs as far east as Medicine Hat in Alberta. See: Detling in Amer. Midl. Nat. 22:511, 1939.

D. richardsonii (Sweet) O. E. Schulz (*Sophia richardsoniana* (Sweet) Rydb.).—Grey Tansy Mustard. Frequent on river banks, roadsides, waste places and cultivated fields.

**D. sophia* (L.) Webb ex Prantl (*Sisymbrium sophia* L.; *Sophia sophia* (L.) Britt.; *S. multifida* Gilib.).—Flixweed. Common in cultivated fields, waste places and roadsides.

**Diplotaxus muralis* DC.—Sand Rocket. Waste places. Beaverdale, Fenwood, Saskatoon (UNS).

Draba aurea Vahl.—Golden Whitlow-grass. On turfy slopes and rock crevices at Lake Athabaska (Raup).

D. cinerea Adams.—Ashy Whitlow-grass. Occasional on dry ridges and old beaches of Lake Athabaska (Raup).

D. lanceolata Royle (*D. cana* Rydb.).—Hoary Whitlow-grass. Occasional in rock crevices and turfy slopes at Lake Athabaska (Raup).

D. nemoralis L.—Wood Whitlow-grass. Occasional in dry, open woods, clearings and exposed banks; widely distributed.

D. nemoralis var. *leiocarpa* Lindb.—(*D. lutea* Gilib.).—Associated with the species. In the southern part of our area the typical form is predominant, whereas, northward the glabrous-fruited var. *leiocarpa* is the common form.

**Eruca sativa* Lam. (*Eruca eruca* (L.) Britt.; *Brassica eruca* L.).—Garden Rocket. Waste places. Indian Head, Regina, Seemans.

**Erucastrum gallicum* (Willd.) Schulz (*E. polochi* Schimper & Spenner).—Dog Mustard. Noxious weed in grain fields, waste places and along roadsides.

Erysimum asperum (Nutt.) DC. (*Cheirinia aspera* (Nutt.) Rydb.; *E. capitatum* [*E. elatum*] of reports from Sask., not Greene).—Prairie Rocket. Common on dry sandy prairie. *E. capitatum* (Dougl.) Greene does not occur east of the Rocky Mountains.

E. cheiranthoides L. (*C. cheiranthoides* (L.) Link).—Wormseed Mustard. Frequent in woodland clearings and stream banks. Appears to be native in our area.

E. inconspicuum (S. Wats.) MacM. (*C. inconspicua* (S. Wats.) Britt.; *E. parviflorum* Nutt., not Pers.).—Small-flowered Prairie Rocket. Common on prairie.

Halimolobus virgata (Nutt.) O. E. Schulz (*Arabidopsis glauca* (Nutt.) Rydb.; *A. stenocarpa* Rydb.; *Stenophragma virgata* (Nutt.) Greene).—Mouse-ear Cress. Eroded hillsides. Vawn (UNS); Wood Mtn., Cypress Hills (CAN); Mortlach (DAO); Sutherland (DAS). Perhaps not distinct from *H. hookeri* (Lange) Rollins. See Porsild in Sargentia 4:43, 1943.

**Hesperis matronalis* L.—Sweet Rocket. Waste places; occasionally escaped from cultivation. Swift Current (SWC, UNS).

Hutchinsia procumbens (L.) Desv. Little Ingelbright Lake near Fox Valley (DAS).

**Lepidium densiflorum* Schrad. (*L. apetalum* of Amer. auth., not Willd.; *L. bourgeauanum* Thellung).—Common Pepper-grass. A common weed in cultivated fields, gardens and waste places.

**L. perfoliatum* L.—Round-leaved Pepper-grass. Railway embankment at Swift Current (DASC, UNS, DAO).

L. ramosissimum A. Nels. (*L. divergens* Osterh.; *L. fletcheri* Rydb.).—Branched Pepper-grass. Probably not rare. Swift Current (DASC, UNS, DAO); Mortlach (DAO).

**L. sativum* L.—Garden Cress. Occasionally escaped from cultivation.

Lesquerella alpine (Nutt.) S. Wats. var. *spathulata* (Rydb.) Payson (*L. spathulata* Rydb.; *Vesicaria alpina* of Macoun, Cat. Can. Plants, not Nutt.).—Spatulate Bladderpod. Occasional on dry hills and prairie. Wood Mountain Post (CAN); Cypress Hills, Swift Current, Val Marie (UNS, DASC, DAO). For "A Monograph of the Genus Lesquerella" see Payson in Ann. Mo. Bot. Gard. 8:103-236, 1921.

L. arenosa (Richards.) Rydb. (*L. ludoviciana* (Nutt.) S. Wats. var. *arenosa* S. Wats.; *L. rosea, L. versicolor, L. macounii* Greene; *L. prostrata* of report from Sask. by Rydb., Fl. Rocky Mts., & Adj. Pl., not S. Wats.; *Vesicaria ludoviciana* of Macoun, Cat. Can. Plants, not S. Wats.).—Sand Bladder Pod. Frequent on dry exposed hills in the prairie region.

**Macloviana africana* (Willd.) R. Br.—African Stock. Swift Current. Escaped from cultivation; not established.

**Neslia paniculata* (L.) Desv.—Ball Mustard. Common weed in cultivated fields.

**Rhaphanus raphanistrum* L. (*Rhaphanistrum inocuum* Moench).—Wild Radish. Tisdale (DAO). A weed associated with a serious infestation of Indian Mustard (*Brassica juncea*) in a cultivated field of Flax (*Linum usitatissimum*).

**Rhaphanistrum perenne* (L.) All.—Perennial Mustard. Waste place. Grenfell (UNS).

**Rorippa austriaca* (Crantz) Besser (*R. sylvestris* of Groh in Scientific Agriculture 16(6):331-34, 1936, in part, not Besser).—Austrian Cress. In cultivated field at Greenstreet (DAO). Determined by R. C. Rollins.

R. islandica (Oeder ex Murray) Borbas var. *fernaldiana* Butters & Abbe (*R. islandica* var. *microcarpa* (Regel.) Fern., not forma *microcarpa* (G. Beck) Thell.; *R. palustris* of auth., not (L.) Besser).—Marsh Yellow-cress. Common on shores of lakes and sloughs.

R. islandica var. *hispida* (Desv.) Butters & Abbe (*R. palustris* var. *hispida* (Desv.) Robins.; *R. hispida* (Desv.) Britt.; *R. islandica* var. *glabra* (Lunell) Butters & Abbe; *Radicula hispida* (Desv.) Heller).—Hairy Yellow-cress. Frequent on damp shores.

R. sinuata (Nutt.) Hitchc. (*Radicula sinuata* (Nutt.) Greene; *R. columbiae* of Fraser and Russell, not Suksd.).—Spreading Yellow-cress. In damp depressions. Kabri (UNS); Kindersley, Tessier (UNS, DAS, as *R. columbiae*); Indian Head (DAO, as *R. curvilisqua*).

**R. sylvestris* (L.) Besser (*Nasturtium sylvestre* (L.) R. Br.; *Radicula sylvestris* (L.) Druce).—Creeping Yellow Water-cress. In cultivated fields and gardens. Regina, Leader (DAO).

**Sisymbrium altissimum* L. (*Norta altissima* (L.) Britt.).—Tumble Mustard. Common weed in grain fields and waste places.

**S. loeselii* L.—Tall Hedge Mustard. Occasional in waste places. Carlyle, Kendal, Lebret, Saskatoon, Stony Beach.

Subularia aquatica L.—Awlwort. In cold lakes. Amisk Lake (DAS).

**Thlaspi arvense* L.—Penny Cress, Stinkweed. Common weed in cultivated fields.

CAPPARIDACEAE—Caper Family

Cleome serrulata Pursh (*Pteritoma serrulatum* (Pursh) DC.; *C. integrifolia* Torr. & Gray).—Pink Cleome. Frequent on sandy prairie and weedy along roadsides.

Polanesia trachysperma Torr. & Gray (*P. graveolens* of reports from Sask., not Raf.). —Western Clammy-weed. Sandy soil and eroded hillsides in the prairie region. Gull Lake, Island Lake, Long Lake (CAN); Mortlach (DAO); Saskatchewan Landling, Katepwa, Maple Creek (UNS, DASC).

RESEDACEAE—Mignonette Family

**Reseda alba* L.—White Cut-leaved Mignonette. Waste place at Brock (UNS).

**R. lutea* L.—Yellow Cut-leaved Mignonette. Waste places. Grenfell, Spy Hill, Swift Current (UNS, DAO, DASC).

DROSERACEAE—Sundew Family

Drosera anglica Huds. (*D. intermedia* of Sask. reports, not Hayne).—Oblong-leaved Sundew. Bogs northward. Prince Albert, McKague (UNS, DAO); Lake Athabaska (Raup).

D. linearis Goldie.—Slender-leaved Sundew. Occasional in bogs northward. Prince Albert, McKague (UNS, DAO).

D. rotundifolia L.—Round-leaved Sundew. Sphagnum swamps and bogs. McKague, Speddington, Prince Albert, Waskesiu Lake (UNS, DAO); Lake Athabaska (Raup).

SARRACENIACEAE—Pitcher-plant Family

Sarracenia purpurea L.—Pitcher-plant. Occasional in bogs northward. McKague, Prince Albert, Nipawin, Chelan, Bjorkdale; Lake Athabaska (Raup).

CRASSULACEAE—Stone-crop Family

**Sedum aizoon* L.—Stone-crop. Escaped from cultivation; not established. Saskatoon (UNS).

S. stenopetalum Pursh (*S. douglasii* of report from Sask. by Macoun, Cat. Can. Plants, not Hook.).—Narrow-petaled Stone-crop. Exposed grassy slopes and ridges. Cypress Hills, Swift Current (CAN, UNS, DAO, DASC).

SAXIFRAGACEAE—Saxifrage Family

Chrysosplenium tetrandrum (Lund) Fries (*C. iowense* Rydb.; *C. americanum* of reports from Sask., not Schwein.).—Northern Golden Saxifrage. In wet spruce woods. McKague, Torch River, Waskesiu Lake (UNS, DAO).

Heuchera richardsonii R. Br. (*H. hispida* of western auth., not Pursh).—Richardson's Alum Root. Common on prairie and borders of woods.

Lithophragma bulbifera Rydb.—Star Flower. In moist coulee near Robsart (UNS); Cypress Hills (DAS).

Mitella nuda L.—Mitrewort. Common in spruce woods.

Parnassia glauca Raf. (*P. americana* Muhl.; *P. caroliniana* of most auth., not Michx.).—Glaucous Grass-of-Parnassus. Cold bogs northward. Nipawin, Prince Albert; Crystal Lake 40 miles north of Yorkton (UNS, DAO).

P. kotzebuei Cham. & Schl.—Alpine Grass-of-Parnassus. Axis Lake near east end of Lake Athabaska (DAO, UNS).

P. montanensis Fern. & Rydb.—Mountain Grass-of-Parnassus. Shore of Lake Athabaska (Raup).

P. palustris L. ssp. *neogaea* (Fern.) Hultén (var. *neogaea* Fern.; *P. multiseta* of Amer. auth., not *P. palustris* var. *multiseta* Ledeb.).—Meadow Grass-of-Parnassus. Common in wet thickets, swamps and marshes; widely distributed.

Ribes americanum Mill. (*R. floridum* L'Her.).—Wild Black Currant. Common among thickets in rich alluvial river valleys.

R. aureum Pursh (*Chrysobotrya aurea* (Pursh) Rydb.).—Golden Currant. Thickets in valley of the Frenchman River near east end of the Cypress Hills (UNS, DAO, DASC); Mortlach (DAO). According to J. H. Hudson, Can. Field-Nat. 65:205, 1951, *R. aureum* has "escaped from cultivation in our [Mortlach] area; well established on sandy soils." His specimen has the hypanthium tube 9-10 mm long, thus agreeing with *R. aureum*.

F. glandulosum Grauer (*R. prostratum* L'Her.).—Skunk Currant. Occasional in swampy woods and alder thickets northward.

R. hirtellum Michx. (*Grossularia hirtella* (Michx.) Spach; *R. saxosum* Hook.).—Low Wild Gooseberry. Moist woods in the central part of the area. Bjorkdale, Madge Lake, Moose Range, Wallwort (UNS); Runciman, Tisdale (DAO); McKague (UNS, DAO).

R. hudsonianum Richards.—Northern Black Currant. Common in coniferous woods.

R. lacustre (Pers.) Poir. (*Limnobotrya lacustris* (Pers.) Rydb.).—Bristly Black Currant. Frequent in swamps and wet woods.

R. oxyacanthoides L. (*G. oxyacanthoides* (L.) Mill.).—Northern Gooseberry. Common in aspen woods, thickets and rocky hills, especially northward.

R. setosum Lindl. (*G. setosa* (Lindl.) Cov. & Britt.).—Bristly Gooseberry. Common on moist depressions in the prairie region. Perhaps not distinct from *R. oxyacanthoides*.

R. triste Lindl. Wild Red Currant. Frequent in rich woods.

Saxifraga rhomboidea Greene (*Micranthes rhomboidea* (Greene) Small).—Rhomboid-leaved Saxifrage. Grassy slopes of the Cypress Hills (UNS, DASC, DAO).

S. tricuspidata Rottb. (*Leptasea tricuspidata* (Rottb.) Haw.).—Three-toothed Saxifrage. On outcrops of the Precambrian Shield northward. Lac la Ronge (DAO); Reeve's Lake (UNS); Lake Athabaska (Raup).

ROSACEAE—Rose Family

Agrimonia striata Michx.—Grooved Agrimony. Occasional in woods and thickets. Meadow Lake, Oxbow, Saskatoon, Mortlach, McKague.

Amelanchier alnifolia (Nutt.) Nutt. (*Aronia alnifolia* Nutt.; *Amelanchier carrii* Rydb.; *A. humilis* of Raup, not Wieg.; *A. florida* of Raup, not Lindl.; *A. canadensis* of western reports, not Medic.).—Saskatoon Service-berry. Common on river banks, margins of woods, etc. For complete synonymy see: G. N. Jones in Ill. Biol. Mon. 20:1-126, 1946.

Chamaerhodos erecta (L.) Bunge ssp. *nuttallii* (Torr. & Gray) Hultén (var. *nuttallii* Torr. & Gray; *C. nuttallii* (Torr. & Gray) Pickering).—American Chamaerhodos. Frequent on dry prairie.

Crataegus chrysocarpa Ashe (*C. rotundifolia* Moench, in part, not Lam.).—Fire-berry Hawthorn. Frequent on dry river banks.

C. columbiana Howell (*C. succulenta* of Fraser and Russell, not Schrad.).—Columbia Hawthorn. Stream banks in the Cypress Hills (UNS, DAO, DASC).

C. douglasii Lindl. (*C. brevispina* (Dougl.) Farwell).—Black-fruited Hawthorn. Shore of Loch Leven in Cypress Hills Park (UNS, DAO, DASC).

Dryas drummondii Richards.—Mountain Avens. Gravelly shore of Lake Athabaska (Raup).

Fragaria vesca L. var. *americana* Porter (*F. americana* (Porter) Britt.).—American Wood Strawberry. Occasional in rocky woods. McKague, Nipawin, Emma Lake, Kenosee Lake (UNS, DAO).

F. virginiana Duchesne var. *glauca* S. Wats. (*F. glauca* (S. Wats.) Rydb.; *F. pauciflora* Rydb.).—Smooth Wild Strawberry. Abundant in woods and on prairie.

Geum allepicum Jacq. ssp. *strictum* (Ait.) R. T. Clausen (var. *strictum* (Ait.) Fern.; *G. strictum* Ait.).—Yellow Avens. Frequent in thickets, woods and clearings.

G. macrophyllum Willd. ssp. *perincisum* Rydb.) Hultén (var. *perincisum* (Rydb.) Raup; *G. perincisum* Rydb.; *G. oregonense* Rydb., not Scheutz; *G. macrophyllum* of Fraser and Russell, not Willd.).—Cut-leaved Avens. Common in sedge meadows and swamps.

G. rivale L.—Purple Avens. Occasional in swamps and low meadows. Cypress Hills, Meadow Lake, Torch River (UNS, DAO).

G. triflorum Pursh (*Sieversia triflora* (Pursh) R. Br.).—Three-flowered Avens. Common and widely distributed on open prairie and hills north to Lake Athabaska.

G. triflorum var *ciliatum* (Pursh) Fassett (*Sieversia ciliata* (Pursh) D. Don).—Ciliate Avens. In fescue grassland on the Cypress Hills plateau (DAO).

Potentilla anserina L. (*Argentina anserina* (L.) Rydb.).—Silver-feather. Common in damp meadows, river and lake shores. Leaflets green and glabrous above, silvery-silky beneath.

P. anserina forma *sericea* (Hayne) Hayek (*P. anserina* var. *argentea* (Rydb.) Jepson; *Argentina argentea* Rydb.).—Sandy and gravelly shores. Associated with the typical species. Leaflets silvery-silky on both sides.

**P. argentea* L.—Silvery Cinquefoil. Weed at Lac la Ronge (DAS, DAO); Parkbeg (DAS).

P. arguta Pursh (*Drymocallis agrimonioides* (Pursh) Rydb.).—White Cinquefoil Frequent on moist prairie and rocky exposures; widely distributed.

P. concinna Richards.—Early Cinquefoil. Common on dry prairie and exposed hills.

P. concinna var. *dissecta* (S. Wats.) Boivin (*P. nivea* var. *dissecta* S. Wats.; *P. concinna* var. *divisa* Rydb.; *P. divisa* (Rydb.) Rydb.).—Cut-leaved Cinquefoil. On dry exposed hills, associated with the typical species. Cypress Hills, Regina (UNS, DAO). See: Boivin in Phytologia 4:89, 1952.

P. diversifolia Lehm. (*P. glaucophylla* Lehm.).—Varying-leaved Cinquefoil. In fescue grassland on the Cypress Hills plateau (UNS, DAO).

P. effusa Dougl.—Branched Cinquefoil. Occasional on dry exposed hills in the prairie region. Cypress Hills, Odessa (UNS, DAO).

P. flabelliformis Lehm. (*P. gracilis* var. *flabelliformis* (Lehm.) Nutt.).—Fan-shaped Cinquefoil. Occasional on moist prairie. Bruno, Carmel, Chaplin, Pike Lake, Saskatoon, Viscount, Regina, Kenaston.

P. fruticosa L. (*Dasiphora fruticosa* (L.) Rydb.).—Shrubby Cinquefoil. Frequent in muskegs northward and abundant in grassland on the Cypress Hills plateau.

P. gracilis Dougl. ex Hook. ssp. *nuttallii* (Lehm.) Keck (*P. nuttallii* Lehm.; *P. rigida* Nutt., not Wall.; *P. gracilis* var. *rigida* (Nutt.) S. Wats.; *P. jucunda* A. Nels.; *P. blaschkeana* Turcz.; *P. brunnescens* of Fraser and Russell, not Rydb.).—Nuttall's Cinquefoil. Common on prairie, open slopes and in valleys. For complete synonymy see: Keck in Carn. Inst. Wash. Publ. 520:134-6, 1940. According to Keck, typical *P. gracilis* is coastal occurring from Alaska to California.

P. gracilis var. *pulcherrima* (Lehm.) Fern. (*P. pulcherrima* Lehm.; *P. camporum, P. filipes* Rydb.).—Beautiful Cinquefoil. Common and widespread on prairie.

P. hippiana Lehm.—Wooly Cinquefoil. Occasional on dry hills and plains. Gainsborough, Cadillac, Cypress Hills, Hudson Bay Junction, Swift Current, Saskatoon, Macdowall.

P. hippiana var. *agryrea* (Rydb.) Boivin (*P. argyrea* Rydb.).—Occasional on dry plains. Bienfait, Cypress Hills, Mortlach, Pike Lake, Saskatoon.

P. multifida L.—Cut-leaved Cinquefoil. Rocky shore of Lake Athabaska (Raup).

P. nivea L. (*P. nipharga* Rydb.).—Snowy Cinquefoil. Rocky hills. Lake Athabaska (Raup).

P. nivea var. *pentaphylla* Lehm. (*P. quinquefolia* Rydb.; *P. hookeriana* of Sask. reports not Lehm.).—Five-foliolate Cinquefoil. Dry hills and prairie. Leslie (DAS); Saskatoon (UNS, DAS, NY); Lake Athabaska (Raup).

P. norvegica L. (*P. monspeliensis* L.; *P. hirsuta* Michx.).—Rough Cinquefoil. Common in wet sedge meadows, clearings and waste places. Probably both native and introduced.

P. palustris (L.) Scop. (*Comarum palustre* L.).—Marsh Cinquefoil. Occasional in marshes and bogs. McKague, Crooked River, Waskesiu Lake, Cypress Hills, Crane Lake (UNS, DAO); Lake Athabaska (Raup).

P. paradoxa Nutt. ex Torr. & Gray (*P. nicolletii* (S. Wats.) Sheldon).—Strange Cinquefoil. Gravelly shores. Long Lake, Saskatoon, Moose Mtn. Park, Yorkton, Nipawin, Humboldt, Saskatchewan Landing, Mortlach (UNS, DAO, DASC).

P. pectinata Raf. (*P. litoralis* Rydb.).— Coast Cinquefoil. Rocky crevices on Precambrian outcrops around Lake Athabaska (Raup).

P. pensylvanica L. (*P. strigosa* Rydb., not Pall.; *P. atrovirens, P. lasiodonta, P. platyloba* Rydb.).—Prairie Cinquefoil. Common on dry prairie.

P. pensylvanica var. *bipinnatifida* (Dougl.) Torr. & Gray (*P. bipinnatifida* Dougl.). —Plains Cinquefoil. Frequent on open prairie.

P. pensylvanica var. *glabrata* (Hook.) S. Wats. (*P. glabrella* Rydb.).—Glabrate Cinquefoil. Sandy prairie. Wordsworth, Humboldt, Indian Head, Saskatoon, Hudson Bay Junction.

P. plattensis Nutt.—Low Cinquefoil. Frequent on moist prairie.

**P. recta* L. (*P. sulphurea* Lehm.).—Upright Cinquefoil. Railway embankments. Swift Current, Mortlach (DAO).

P. rivalis Nutt. ex Torr. & Gray.—Brook Cinquefoil. A specimen collected by Macoun at Little Crane Lake was determined by P. A. Rydberg (CAN).

P. rivalis var. *millegrana* (Engelm.) S. Wats. (*P. millegrana* Engelm.; *P. biennis* Greene).—Diffuse Cinquefoil. Shores of lakes and rivers. Mortlach, Duval, Pike Lake, Prudhomme, Stewart Valley, McKague, Hudson Bay Junction, Meadow Lake.

P. rivalis var. *pentandra* (Engelm.) S. Wats. (*P. pentandra* Engelm.).—Five-stamened Cinquefoil. Damp meadows. Specimens collected by Macoun at Touchwood and Yorkton were determined by P. A. Rydberg (CAN).

P. tridentata (*Sibbaldiopsis tridentata* (Ait.) Rydb.).—Three-toothed Cinquefoil. Frequent in sandy pine woods and rocky outcrops northward. Crutwell, Emma Lake, Meadow Lake, Pre Ste. Marie, Prince Albert, Candle Lake, Waskesiu Lake.

Prunus americana Marsh.—Wild Plum. On river banks. Roche Percée, Estevan (DAO, DASC).

P. pensylvanica L.f.—Pin Cherry. Common on dry hillsides in wooded areas.

P. pumila L. var. *besseyi* (Bailey) Gleason (*P. besseyi* Bailey).—Western Sand Cherry. Sand hills and open plains. Hudson Bay Junction, Welby (DAO).

P. virginiana L. var. *melanocarpa* (A. Nels.) Sarg. (*P. melanocarpa* (A. Nels.) Rydb.).—Black-fruited Choke Cherry. Common on sandy soil and river banks. Fruit commonly black, or yellow in the rare forma *xanthocarpa* Sarg., which occurs in the Lightwoods district west of McKague and reported from Yorkton in The Blue Jay 9(4):22, 1951.

Rosa acicularis Lindl.—Prickly Rose. Common in woodlands, fence rows and river banks. Plants with subglobose fruit are sometimes segregated as var. *bourgeauana* (Crep.) Crep.

R. arkansana Porter (*R. subglauca*, Rydb.; *R. lunellii* Greene).—Prairie Rose. Common on prairie and plain. Plants having leaflets densely pubescent, at least beneath, may be distinguished, if desired, as var. *suffulta* (Greene) Cockerell.

R. woodsii Lindl. (*R. fendleri* Crep.; *R. macounii* Greene; *R. blanda* of western reports, not Ait.).—Woods' Rose. Common in aspen groves, on prairie and river banks. In the southwestern part of the area occurs a race armed with stout, rather flattened prickles, known as var. *terrens* (Lunell) Breitung. [Considerable variation exists among our three rose species in fruit shape, shape and size of leaves, pubescence, and spines. Erlanson, Bot. Gaz. 96:231, 1934, states: ". . . many of the characteristics commonly used to distinguish between [rose] species are individual variations. These unreliable characteristics may occur combined in every possible way, sometimes in plants of a single culture."]

Rubus acaulis Michx. (*R. arcticus* var. *grandiflorus* of Amer. auth., not Ledeb.).—Stemless Dewberry. Common in spruce swamps; widely distributed.

R. arcticus L. (*R. paracaulis* Bailey).—Arctic Dewberry. Occasional in coniferous woods. McKague, Tisdale, Candle Lake, Cypress Hills (UNS, DAO, CAN).

R. chamaemorus L.—Cloudberry. Open spruce muskegs northward. Crooked River, Prince Albert, Tisdale, Waskesiu Lake, White Fox, Ile a la Crosse (UNS, DAO); Lake Athabaska (Raup).

R. idaeus L. var. *canadensis* Richards. (*R. strigosus* var. *canadensis* (Richards.) House; *R. subarcticus* Rydb.; *R. melanolasius* of Sask. reports, not Focke).—Canadian Raspberry. Frequent in wooded areas. Var. *aculeatissimus* (*R. melanolasius*) is a Rocky Mountain race.

R. idaeus var. *strigosus* (Michx.) Maxim. (*R. strigosus* Michx.).—Wild Red Raspberry. Common in woods, especially abundant following fire.

R. pubescens Raf. (*R. triflorus* Richards.).—Dewberry. Common in rich woods.

**Sorbaria sorbifolia* (L.) A. Br. (*Schizanthus sorbifolius* (L.) Lindl.).—Ash-leaved Spiraea. Escaped from cultivation at Clearwater Lake (DAS).

Sorbus decora Sarg. (*S. americana* Marsh. var *decora* (Sarg.) Sarg.; *S. scopulina* of Fraser and Russell, in part; *Pyrus decora* (Sarg.) Hyland).—Showy Mountain-ash. In woods; central eastern part of the area. Little Bear Lake about 80 miles NW of Nipawin (DAO); Mistatim (UNS, as *S. scopulina*). Probably common in the Pasquia Hills and Porcupine Mountain.

S. scopulina Greene (*S. sitchensis* of Raup, l.c. 264, not Roem.).—Western Mountain-ash. Occasional on wooded slopes in the Cypress Hills (UNS, DAO); beach ridges at Lake Athabaska (Raup, as *S. sitchensis*). See: J. Arn. Arb. 20:18, 1939.

Spiraea alba Du Roi.—Narrow-leaved Meadow-sweet. Common on low prairie.

S. lucida Dougl.—Shining-leaved Meadow-sweet. Common in lodgepole pine woods in the Cypress Hills.

LEGUMINOSAE (Fabaceae)—Pea Family

Astragalus aboriginum Richards. (*Atelophragma aboriginum* (Richards.) Rydb.; *A. glabriusculum* (Hook.) Rydb.; *A. herriotii*, *A. lineare* Rydb.).—Indian Milk Vetch. On semi-wooded river banks. Cypress Hills (CAN); Saskatoon, Ceepee, Qu'Appelle (UNS, DAO).

A. agrestis Dougl. ex G. Don (*A. goniatus* Nutt.; *A. hypoglottis* Richards., not L.)—Purple Milk Vetch. Common on moist prairie.

A. alpinus L. (*Atelophragma alpinum* (L.) Rydb.).—Alpine Milk Vetch. Pelly, Assiniboia, Preeceville (UNS); Lake Athabaska (Raup).

A. americanus (Hook.) M. E. Jones (*Phaca americana* Hook.).—American Rattlepod. Borders of rocky woods. McKague, Cypress Hills, Kenosee Lake, Turtle Lake, Meadow Lake.

A. bisulcatus (Hook.) A. Gray (*Diholcus bisulcatus* (Hook.) Rydb.).—Two-grooved Milk Vetch. Common on plains and in river valleys.

A. canadensis L.—Canadian Milk Vetch. Common in thickets on river banks.

A. crassicarpum Nutt. (*A. caryocarpus* Ker; *Geoprumnon crassicarpum* (Nutt.) Rydb.; *A. succulentus* Richards.).—Buffalo Bean, Ground Plum. Occasional on dry prairie and hills. See: Amer. Midl. Nat. 55:496-498, 1956.

A. drummondii Dougl. (*Tium drummondii* (Dougl.) Rydb.).—Drummond's Milk Vetch. Dry exposed hillsides and prairie. Cypress Hills, Battleford, Climax, Cochin, Langham.

A. eucosmus Robins. (*Atelophragma elegans* (Hook.) Rydb.).—Elegant Milk Vetch. Openings on river banks. Prince Albert (CAN); Beaver Creek, Candle Lake, Saskatoon (DAO); Lake Athabaska (Raup).

A. flexuosus Dougl. ex Hook. (*Pisophaca flexuosa* (Dougl.) Rydb.).—Flexile Milk Vetch. Frequent on dry prairie and plain.

A. kentrophyta A. Gray (*A. montanus* (Nutt.) M. E. Jones, not L.; *Kentrophyta montana* Nutt.).—Prickly Milk Vetch. Sand hills near Stinking Lake (CAN); Webb (UNS, DASC).

A. lotiflorus Hook. (*Batidophaca lotiflora* (Hook.) Rydb.; *Phaca elatiocarpa* (Sheld.) Rydb.; *Xylophacos purshii* of reports from Sask., not Rydb.).—Low Milk Vetch. Hills and plains. Sutherland, Watrous, Elbow, Webb (UNS); Saskatoon, Pike Lake, Swift Current, Mortlach (DAO).

A. missouriensis Nutt. (*Xylophacos missouriensis* (Nutt.) Rydb.).—Missouri Milk Vetch. Dry plains. Saskatoon, Saskatchewan Landing, Langham, Fort Qu'Appelle, Dundurn, Beaver Creek (UNS); Cypress Hills, Mortlach (DAO).

A. pectinatus (Hook.) Dougl. (*Chemidophacos pectinatus* (Nutt.) Rydb.).—Narrow-leaved Milk Vetch. Common on dry prairie and hills.

A. racemosus Pursh (*Tium racemosum* (Pursh) Rydb.).—Racemose Milk Vetch. Dry hillsides. Moose Jaw Creek (CAN); Saskatoon (UNS).

A. spatulatus Sheld. (*A. caespitosus* (Nutt.) A. Gray, not Pall.; *Homalobus caespitosus* Nutt.).—Tufted Milk Vetch. Dry hills and plains. Cypress Hills (DAO); Eatonia, Govenlock (UNS, DASC).

A. striatus Nutt. ex Torr. & Gray (*A. adsurgens* Hook., not Pall.).—Grooved Milk Vetch. Frequent on dry prairie and hillsides.

A. tenellus Pursh (*Homalobus tenellus* (Pursh) Britt.; *H. stipitatus* Rydb.).—Loose-flowered Milk Vetch. Frequent on dry prairie.

A. triphyllus Pursh (*Phaca caespitosa* Nutt.; *Orophaca caespitosa* (Nutt.) Britt.).—Cushion Milk Vetch. Frequent on dry hills and plains.

A. vexilliflexus Sheldon (*A. pauciflorus* Hook., not Pall.; *Homalobus vexilliflexus* (Sheldon) Rydb.).—Few-flowered Milk Vetch. Exposed summits of the Cypress Hills (CAN, DAO, UNS); Rockglen in Wood Mtn. District (DAS).

**Caragana arborescens* Lam.—Caragana. Occasionally escaped from cultivation.

Glycyrrhiza lepidota (Nutt.) Pursh.—Wild Licorice. Common on low prairie.

Hedysarum alpinum L. ssp. *americanum* (Michx. ex Pursh) Fedtch. (var. *americanum* Michx.; *H. americanum* (Michx.) Britt.; *H. philoscia* A. Nels.; *H. boreale* A. Gray, not Nutt.).—American Hedysarum. Common in rocky woods and prairie.

H. boreale Nutt. var. *cinerascens* (Rydb.) Rollins (*H. cinerascens* Rydb.; *H. mackenzii* of Macoun, Cat. Can. Plants, in part).—Northern Hedysarum. Occasional on dry, exposed hillsides in the prairie region. Bengough, Mortlach, Biggar, Elbow, Indian Head, Lac Pelletier, Yellow Grass (UNS); Cypress Hills, Moose Jaw (CAN, as *H. mackenzii*). See: Rollins in Rhodora 42:217-239, 1940.

H. mackenzii Richards.—Mackenzie's Hedysarum. Along the north Saskatchewan River at Langham and Le Cole Falls (UNS).

Lathyrus ochroleucus Hook.—Cream-colored Pea-vine. Common in aspen woods.

L. palustris L. Marsh Vetchling. Sedge meadows. McKague, Tisdale, Canora (UNS).

L. venosus Muhl. ex Willd. var. *intonsus* Butters & St. John.—Veiny Pea-vine. Common in woods northward.

Lotus purshianus (Benth.) Clements & Clements (*Hosackia purshiana* Benth.; *Lotus americanus* (Nutt.) Bisch.; *Acmispon americanus* (Nutt.) Rydb.).—Prairie Birdfoot Trefoil. Low prairie. Gainsborough (UNS, DAS); Carievale, Bromhead (DAO).

Lupinus argenteus Pursh var. *macounii* (Rydb.) Davis (*L. leucopsis* of reports from Sask., not Agardh.).—Macoun's Silvery Lupine. Abundant in the Cypress Hills (UNS, CAN, DAO, DASC); Maple Creek (UNS). Pink and white forms occur also, but rarely. *Lupinus leucopsis* does not occur east of the Rocky Mountains.

L. pusillus Pursh (*L. kingii* of Macoun's report from Sask., not S. Wats.).—Small

Lupine. Sand dunes. Beverly (DASC, UNS); Mortlach (DAO); Kindersley (CAN, as *L. kingii*).

**Medicago falcata* L.—Yellow Lucerne. Escaped from cultivation. Hudson Bay Junction, Saskatoon (UNS, DAO).

**M. hispida* Gaertn.—Bur-clover. Introduced weed at Spalding (DAS).

**M. lupulina* L.—Black Medic. Weed in fields and waste places. Indian Head, Saskatoon, Valparaiso (UNS, DAO).

**M. sativa* L.—Alfalfa. Cultivated and escaped in many localities.

**Melilotus alba* Desr.—White Sweet Clover. Cultivated and escaped along roadsides.

**M. officinalis* (L.) Lam.—Yellow Sweet Clover. Cultivated and frequently escaped.

Oxytropis besseyi (Rydb.) Blank. (*Aragallus besseyi* Rydb.).—Bessey's Locoweed. Dry prairie hillside. Canopus (DAO, DAS). Not previously collected in Canada.

O. campestris (L.) DC. var. *gracilis* (A. Nels.) Barneby (*O. gracilis* (A. Nels.) K. Schum.; *O. villosa* (Rydb.) K. Schum.; *Aragallus gracilis* A. Nels.).—Late Yellow Loco-weed. Common on prairie. Blooms in July.

O. deflexa (Pall.) DC. var. *sericea* Torr. & Gray (*O. retrorsa* Fern. var. *sericea* (Torr. & Gray) Fern.; *Aragallus deflexus* (Pall.) Heller).—Pendent-pod Loco-weed. Frequent on prairie and in valleys. *O. deflexa*, sens. lat. is a variable circumboreal species. In America, it may, if desired, be segregated into the subacaulescent *O. deflexa* var. *foliosa* (Hook.) Barneby, and the var. *sericea* Torr. & Gray with a well developed and elongated stem. Var. *foliosa* may possibly occur in the northern part of our area also.

O. lambertii Pursh (*Aragallus lambertii* (Pursh) Greene; *O. albertina* (Greene) Rydb.).—Lambert's Loco-weed. Dry hillsides. Bienfait, Estevan (UNS, DAS).

O. sericea Nutt var. *spicata* (Hook.) Barneby (*O. spicata* (Hook.) Standley; *O. macounii* (Greene) Rydb.; *Aragallus spicatus* (Hook.) Rydb.).—Early Loco-weed. Common on dry prairie and exposed hills. Blooms in May.

O. splendens Dougl. (*O. richardsonii* (Hook.) K. Schum.; *Aragallus splendens* (Dougl.) Greene; *A. gilioides*, *A. melanodontus* Greene).—Showy Loco-weed. Dry prairie and exposed river banks. Cumberland House (GH); Bladworth, Drake, Saskatoon, Balcarres, Gillespie, Kelliher, Oxbow, Viscount (UNS).

Petalostemon candidum (Willd.) Michx.—White Prairie-clover. Frequent on moist prairie in SE Saskatchewan.

P. candidum var. *occidentale* A. Gray. (*P. occidentale* (A. Gray) Fern.; *P. oligophyllus* (Torr.) Rydb.).—Slender White Prairie-clover. Common on dry prairie and eroded hillsides. Stems decumbent or ascending.

P. purpureum (Vent.) Rydb.—Purple Prairie-clover. Common on dry prairie.

P. purpureum forma *pubescens* (A. Gray) Fassett (*P. mollis* Rydb.).—Uncommon on dry prairie. Cypress Hills (DAO); Bare Hills (CAN); Snipe Lake (DAS).

Psoralea argophylla Pursh (*Psoralidium argophyllum* (Pursh) Rydb.).—Silver-leaved Psoralea. Frequent on open prairie.

P. esculenta Pursh (*Pediomelon esculentum* (Pursh) Rydb.).—Indian Bread-root. Frequent on dry prairie.

P. lanceolata Pursh (*Psoralidium lanceolatum* (Pursh) Rydb.).—Lance-leaved Psoralea. Frequent on sand hills and sandy prairie.

Thermopsis rhombifolia Nutt. ex. Richards. (*T. arenosa* A. Nels.).—Golden Bean. Common on prairie.

**Trifolium hybridum* L.—Alsike Clover. Cultivated to some extent and escaped along roadsides.

**T. pratense* L.—Red Clover. Occasional in roadside ditches; escaped.

**T. procumbens* L.—Low Yellow Clover. Waste places. Prairie River (UNS, DAO); Bannock (DAS).

**T. repens* L.—White Clover. Occasionally escaped from lawn and pastures.

**Trigonella coerulea* Ser.—Sweet Trefoil. Weed in cultivated grass. Swift Current, Saskatoon (UNS).

Vicia americana Muhl. ex Willd.—American Vetch. Common in aspen woods.

V. americana var. *angustifolia* Nees (*V. sparsifolia* Nutt.).—Narrow-leaved Vetch. Frequent on dry prairie.

V. americana var. *truncata* (Nutt.) Brewer (*V. oregona* Nutt.; *V. trifida* Dietr.).—Pubescent Vetch. Occasional on moist prairie.

**V. cracca* L.—Tufted Vetch. Occasional in cultivated fields and along roadsides. Bruno, Maple Creek, Peesane, Saskatoon, Tisdale.

GERANIACEAE—Geranium Family

***Erodium cicutarium** (L.) L'Her. ex Ait. Storkbill.—Weed in waste places. Regina, Kinestino (UNS).

Geranium bicknellii Britt. (*G. longipes* (S. Wats.) Gooding).—Bicknell's Wild Geranium. Common in woods and clearings.

G. carolinianum L. var. **sphaerospermum** (Fern.) Breitung, stat. nov. (*G. sphaerospermum* Fern., Rhodora 37:298, 1935).—Carolina Wild Geranium. Occasional in open rocky woods and roadsides. Kenosee Lake, Kinestino (UNS); Cypress Hills, Meadow Lake (DAO).

G. richardsonii Fisch. & Trautv. (*G. albiflorum* Hook.).—Richardson's Wild Geranium. Frequent in aspen woods in the Cypress Hills.

G. viscosissimum Fisch. & Mey.—Sticky Purple Geranium. Moist valleys. Cypress Hills, Touchwood Hills (DAO); Killdeer (UNS, as *G. incisum*); Wood Mtn. Post (CAN, as *G. strigosum*).

OXALIDACEAE—Wood-sorrel Family

Oxalis europaea Jord. (*Xanthoxalis bushii* Small).—Yellow Wood-sorrel. Probably introduced into our area. McKague (UNS, DAO, as *X. corniculata*); Meadow Lake (UNS, as *X. bushii*).

O. stricta L. (*X. stricta* (L.) Small).—Upright Wood-sorrel. Prairie, thickets and glades. Wordsworth (UNS, as *X. bushii*); Sidewood (UNS, as *X. corniculata*); Trossachs, Swift Current, North Battleford, Portal (UNS).

LINACEAE—Flax Family

Linum perenne L. ssp. *lewisii* (Pursh) Hultén (*L. lewisii* Pursh; *L. sibiricum* DC. var. *lewisii* (Pursh) Lindl.; *L. perenne* var. *lewisii* (Pursh) Eaton & Wright; *L. pratense* (Norton) Small).—Lewis' Wild Blue Flax. Common on dry prairie and exposed hillsides.

L. rigidum Pursh (*Cathartolinum regidum* (Pursh) Small; *C. compactum* (A. Nels.) Small; *C. sulcatum* of Fraser and Russell, not Small).—Yellow Flax. Frequent on dry prairie.

BALSAMINACEAE—Jewel-weed Family

Impatiens biflora Walt. (*I. capensis* Meerburgh; *I. fulva* Nutt.).—Spotted Touch-me-not. Occasional in damp woods. McKague, Kamsack, Madge Lake, Pike Lake, Wallwort, Waskesiu Lake.

I. noli-tangere L. (*I. occidentalis* Rydb.).—Western Touch-me-not. Springy places in woods northward. Golburn, Montreal Lake, Waskesiu Lake (DAO, UNS).

POLYGALACEAE—Milkwort Family

Polygala alba Nutt.—White Milkwort. Dry hillsides. Bengough, Ceylon, Roche Percée (UNS).

P. paucifolia Willd.—Fringed Milkwort. Dry woods. McKague, Shellbrook (DAO, UNS).

P. senega L.—Seneca Root. Common in rocky or sandy semi-wooded areas.

P. senega var. *latifolia* Torr. & Gray.—Collected at McLean by B. J. Sallans (UNS).

EUPHORBIACEAE—Spurge Family

**Euphorbia esula* L. (*E. virgata* Waldst. & Kit.; *Galarrhoeus esula* (L.) Rydb.; *Tithymalus esula* (L.) Hill).—Leafy Spurge. A weed in cultivated fields, difficult to eradicate. Battleford, Caron, Indian Head, Maidstone, Merriott, Rouleau, Wimmer.

**E. lucida* Waldst. & Kit. (*G. lucidus* (Waldst. & Kit.) Rydb.; *T. lucidus* (Waldst. & Kit.) Kl. & Garcke).—Shining Spurge. Cultivated field at Kamsack (DAO).

**E. glyptosperma* Engelm. (*Chamaesyce glyptosperma* (Engelm.) Small).—Ridge-seeded Spurge. Occasional in dry sandy soil. Nipawin, Abbey, Moose Jaw, Pike Lake, Saskatoon, Swift Current, Mortlach.

**E. serpyllifolia* Pers. (*C. serpyllifolia* (Pers.) Small).—Thyme-leaved Spurge. Occasional in waste places and sandy soil. Nipawin, Bracken, Bulyea, Cypress Hills, Indian Head, Langbank, Maple Creek, Swift Current.

CALLITRICHACEAE—Water-starwort Family

Callitriche hermaphroditica L. (*C. autumnalis* L.).—Northern Water-starwort. Occasional in shallow water. Pre Ste. Marie, Beaver Creek, Cypress Hills, Maple Creek.

C. palustris L. (*C. verna* L.).—Vernal Water-starwort. Shallow water and dried up pools. Wallwort, Beaver Creek, Maple Creek, Saskatoon, Wordsworth, Cypress Hills.

EMPETRACEAE—Crowberry Family

Empetrum nigrum L.—Crowberry. Occasional on Sphagnum in black spruce swamps. Nipawin, Bannock, Big River, Bjorkdale, Crooked River, Hudson Bay Junction, Speddington (UNS, DAO); Lake Athabaska (Raup).

ANACARDIACEAE—Sumac Family

Rhus aromatica Ait. var. *trilobata* (Nutt. ex Torr. & Gray) Barkley (*R. canadensis* Marsh. var. *trilobata* (Nutt.) A. Gray; *R. trilobata* Nutt.; *Schmaltzia trilobata* (Nutt.) Small).—Squaw Bush. Dry exposed hillsides in the prairie region. Elbow of the South Saskatchewan River, Big Muddy Valley, Ceylon, Fort Qu'Appelle, Great Sand Hills, Katepwa, Saskatchewan Landing, Cypress Hills.

R. glabra L.—Smooth Sumac. One colony on north shore of Little Birch Lake near Flin Flon (DAS).

R. radicans L. var. *rydbergii* (Small) Rehder (*Toxicodendron rydbergii* (Small) Greene; *T. desertorum* Lunell).—Poison Ivy. Wooded banks and sandhills. Mortlach, Nipawin, Eastend, Cypress Hills, Ravenscrag, Pike Lake, Qu'Appelle Valley, Saskatchewan Landing, Saskatoon (UNS, DAO).

ACERACEAE—Maple Family

Acer negundo L. var. *interius* (Britt.) Sarg. (*A. interior* Britt.; *Negundo interius* (Britt.) Rydb.).—Manitoba Maple. Frequent in river valleys.

A. spicatum Lam.—Mountain Maple. Rich moist woods. Nipawin, Madge Lake, Peesane (UNS, DAO).

RHAMNACEAE—Buckthorn Family

Rhamnus alnifolia L'Her.—Alder-leaved Buckthorn. Frequent in swamps and wet woods.

**R. cathartica* L.—Buckthorn. Escaped from cultivation in some areas and established in nearby woods. Swift Current (UNS, DAO, DASC).

MALVACEAE—Mallow Family

**Abutilon theophrasti* Medic. (*A. abutilon* (L.) Rusby).—Velvet Leaf. Waste places and vacant lots. Biggar (UNS).

**Hibiscus trionum* L. Venice Mallow. Waste places. Vanscoy (UNS), Regina (DAS).

**Malva neglecta* Wallr.—Common Mallow. Common weed in waste places. *M. rotundifolia* L. (*M. parviflora* L.) is an erect plant 2-9 dm high, not found in our area.

**M. verticellata* L. var. *crispa* L. (*M. crispa* L.).—Whorled Mallow. Occasional escape from gardens. Howard, North Battleford (UNS); McKague (DAO).

Sphaeralcea coccinea (Nutt.) Rydb.—Scarlet Mallow. Frequent on dry prairie.

HYPERICACEAE (Guttiferae)—St. John's-wort Family

Hypericum majus (A. Gray) Britt, (*H. canadense* L. var. *majus* A. Gray).—Larger St. John's-wort. Wet shores. Meadow Lake (DAO); Lake Athabaska (Raup); Cypress Hills, Windrum Lake north of Churchill River (CAN); Amisk Lake (DAS).

H. virginicum L. var. *fraseri* (Spach) Fern. (*Triadenum fraseri* (Spach) Gleason). —Fraser's St. John's-wort. Open sedge swamp. Amisk Lake (DAS).

ELATINACEAE—Waterwort Family

Elatine triandra Schk. (*E. americana* of western authors, not Arn.).—Mud Purslane. Bottom of shallow pools. Prince Albert National Park, Saskatoon, Wordsworth (UNS); Mortlach, Parkbeg (DAO).

CISTACEAE—Rock-rose Family

Hudsonia tomentosa Nutt.—Sand Heather. Sandy beach ridges and blow-outs in pine barrens northward. Cutnife, Love (UNS); Prince Albert (UNS, DAO); Lake Athabaska (Raup).

Lechea intermedia Legett var. *depauperata* Hodgdon.—Pine-weed. Burnt-over sandy pine barrens. Lake Athabaska (Raup). See: A. R. Hodgdon in Rhodora 40:127, 1938.

VIOLACEAE—Violet Family

Viola adunca J. E. Smith (*V. subvestita* Greene).—Hooked-spur Violet. Common in sandy, open pine woods and low prairie. The white-flowered forma *albiflora* Vict. & Rousseau was secured at Rosthern (DAS). [Var. *minor* (Hook.) Fern. has been collected at Flin Flon, Manitoba (DAS), by J. H. Hudson, who reports it "plentiful on nearly every rocky ridge on the Manitoba and Saskatchewan sides of the boundary in the Flin Flon area"].

**V. arvensis* Murr.—Wild Pansy. Sandy fields. Wilkie, Canora (DASC, DAO).

**V. kitaibeliana* Roem. & Schult. var. *rafinesque* (Greene) Fern. (*V. rafinesque* Greene).—Field Pansy. In grain field at Tisdale (UNS, DAO).

V. nephrophylla Greene.—Northern Bog Violet. Common in bogs and marshes. The white-flowered forma *albinea* Farw. has been collected at Wallwort (DAO).

V. nuttallii Pursh.—Yellow Prairie Violet. Frequent on dry prairie.

V. nuttallii var. *vallicola* (A. Nels.) St. John (*V. vallicola* A. Nels.; *V. russellii* Boivin).—Yellow Meadow Violet. Occasional on moist prairie meadows. The var. *vallicola* is, perhaps, only an ecological phase of *V. nuttallii*. However, M. S. Baker, Madroño 10:117, 1949, considers them as distinct species, on the basis of chromosome numbers, *V. nuttallii* having 12, whereas *V. vallicola* has 6.

V. palustris L.—Marsh violet. Cool springy places in alder and willow thickets. Muenster, Prince Albert National Park (UNS); McKague, Wallwort (UNS, DAO).

V. pedatifida G. Don.—Crow-foot Violet. Frequent on dry prairie.

V. renifolia A. Gray var. *brainerdii* (Greene) Fern. (*V. brainerdii* Greene).—Kidney-leaved Violet. Occasional in cool, moist spruce woods. Torch River (UNS); McKague, Cypress Hills, Bjorkdale (UNS, DAO).

V. rugulosa Greene (*V. rydbergii* Greene; *V. canadensis* L. var. *rydbergii* (Greene) House; *V. canadensis* of western auth., not L.).—Tall-stemmed White Wood Violet. Common in aspen woods.

V. selkirkii Pursh ex Goldie.—Selkirk's Violet. Coniferous swamp at Amisk Lake (DAS).

LOASACEAE—Loasa Family

Mentzelia decapetala (Pursh) Urban & Gilg (*Nuttalliana decapetala* (Pursh) Greene).—Evening Star. Dry eroded hillsides and badlands in the prairie region. Roche Percée, Cypress Hills, Eastend; Empress on Sask. side of the border.

CACTACEAE—Cactus Family

Mamillaria vivipara (Nutt.) Haw. (*Neomammillaria vivipara* (Nutt.) Rydb.; *Coryphantha vivipara* (Nutt.) Britt. & Rose).—Purple Pincushion or Ball Cactus. Occasional on dry hillsides in the prairie region. Consul, Dundurn, Elbow, Estevan, Lumsden, Matador, Outlook, Swift Current.

Opuntia fragilis (Nutt.) Haw.—Brittle Prickly Pear. Frequent on dry plains. Cadillac, Lac Pelletier, Swift Current.

O. polyacantha Haw.—Many-spined Prickly Pear. Dry plains and exposed river banks, becoming abundant in overgrazed pastures. Battleford, Beaver Creek, Dundurn, Fort Qu'Appelle, Saskatoon, Swift Current, Vidora (UNS); Cypress Hills (DAO).

ELAEAGNACEAE—Oleaster Family

Elaeagnus commutata Bernh. (*E. argentea* Pursh, not Moench).—Silverberry. Common on river banks and sandy prairie.

Shepherdia argentea Nutt. (*Lepargyrea argentea* (Nutt.) Greene).—Thorny Buffalo-berry. Occasional on dry exposed river banks. Langham, Redberry Lake, Saskatchewan Landing, Saskatoon, Eastend, Mortlach.

S. canadensis (L.) Nutt. (*L. canadensis* (L.) Greene).—Low Buffalo-berry. Frequent in wooded areas; widely distributed.

ONAGRACEAE—Evening-primrose Family

Boisduvalia glabella (Nutt.) Walp.—Smooth Boisduvalia. Scarce in moist depressions on prairie. Bracken, Cypress Hills, Mortlach (DAO).

Circaea alpina L.—Small Enchanter's Nightshade. Springy places in forest northward. McKague (DAO); Crooked River, Indian Head, Emma Lake, Waskesiu Lake, Turtle Lake, White Fox (UNS, DAS).

Epilobium adenocaulon Hausskn. (*E. glandulosum* var. *adenocaulon* (Hausskn.) Fern.).—Northern Willow-herb. Common in marshes. Petals white to reddish, 3-4 mm long; plant perennating by subaerial rosettes (rather than turions) from winter buds.

E. adenocaulon var. *perplexans* Trel. (*E. ciliatum* Raf.; *E. americanum* Hausskn.).—American Willow-herb. Springy places. Beaver Creek (DAS); Big River, Earl Grey (UNS). Petals white, 2-3 mm long. Perhaps only a shade phase of *E. adenocaulon*.

E. angustifolium L. (*Chamaenerion angustifolium* (L.) Scop; *C. spicatum* (Lam.) S. F. Gray).—Fireweed. Common in woods, becoming abundant following fire. The white-flowered forma *albiflorum* (Dumort.) Hausskn. has been collected at McKague, Beaver Creek and North Battleford (UNS).

E. glandulosum Lehm.—Glandular Willow-herb. Bjorkdale, John Laycock in 1936 (UNS). Petals 5-10 mm long; plant perennating by large loosely formed subterranean turions. Type locality: Cumberland House Fort, on the Saskatchewan.

E. leptophyllum Raf. (*E. lineare* of auth., not Muhl.; *E. densum* of auth., not Raf.).—Narrow-leaved Willow-herb. Frequent in marshes and swamps.

E. palustre L.—Marsh Willow-herb. Muskegs and wet meadows at Lake Athabaska (Raup).

E. palustre var. *grammadophyllum* Hausskn. (*E. wyomingense* A. Nels.).—Bjorkdale, John Laycock in 1936 (UNS).

E. palustre var. *oliganthum* (Michx.) Fern. (var. *monticola* of Amer. auth., not Hausskn.; *E. oliganthum* Michx.).—Bog Willow-herb. Occasional in swamps and bogs. McKague, Cypress Hills (DAO); Dahlton, Pike Lake (UNS); Lake Athabaska (Raup).

E. paniculatum Nutt. ex Torr. & Gray—Annual Willow-herb. Frequent on prairie and plain. A polymorphous species, represented in Saskatchewan by forma *adenocladon* Hausskn., with capsules and pedicels glandular-puberulent and by forma *subulatum* Hausskn., with capsules and pedicels glabrous.

Gaura coccinea Nutt. ex Pursh.—Scarlet Butterfly Plant. Common on dry prairie and plain.

G. coccinea var. *glabra* (Lehm.) Torr. & Gray (*G. glabra* Lehm.).—Associated with the typical species. Cypress Hills (DAO); Val Marie, Maple Creek, Saskatoon (UNS).

Oenothera biennis L. var. *canescens* Torr. & Gray (*O. strigosa* (Rydb.) Mack. & Bush; *O. biennis* var. *hirsutissima* of Fernald, not A. Gray; *O. muricata* of western reports, not L.).—Common on sandy prairie, becoming weedy along roadsides and railway embankment.

O. breviflora (Nutt.) Torr. & Gray (*Taraxia breviflora* Nutt.).—Taraxia. Rare on plain in southwestern part of the area. Sidewood (UNS).

O. caespitosa Nutt. ex Fraser (*Pachylophus caespitosus* (Nutt.) Raim.; *P. montanus* of Sask. reports, not A. Nels.).—Rock Rose. Frequent on dry prairie and plain.

O. flava (A. Nels.) Garrett (*Lavauxia flava* A. Nels.).—Yellow Lavauxia. Dry eroded river banks. Saskatoon, Regina, Swift Current, Naseby (UNS); Cypress Hills, Mortlach (DAO).

O. nuttallii Sweet (*O. pallida* of auth., not Lindl.; *Anogra nuttallii* (Sweet) A. Nels.).—Nuttall's White Evening Primrose. Frequent on sandy prairie and exposed hillsides.

O. serrulata Nutt. (*Meriolix serrulata* (Nutt.) Walp.; *M. intermedia* Rydb.).—Tooth-leaved Primrose. Frequent on dry hills and plains.

HALORAGIDACEAE (Hippuridaceae)—Water-milfoil Family

Hippurus vulgaris L.—Mare's Tail. Common in lakes and streams.

Myriophyllum pinnatum (Walt.) BSP. (*M. scabratum* Michx.).—Pinnate Water-milfoil. Shallow water in southern part of the prairie region. Wordsworth (UNS); Mortlach (DAO).

M. spicatum L. ssp. *exalbescens* (Fern.) Hultén (var. *exalbescens* (Fern.) Jepson; *M. exalbescens* Fern.).—Spiked Water-milfoil. Common in sloughs, lakes and streams.

M. verticellatum L. var. *pectinatum* Wallr.—Whorled Water-milfoil. Shallow calcareous water. Prince Albert (UNS); Yorkton (DAS). [Perhaps *M. alterniflorum* DC. occurs in the area also].

ARALIACEAE—Ginseng Family

Aralia hispida Vent.—Bristly Sarsaparilla. Dry sandy pine woods and granite outcrops northward. Sulphide Lake in Lac la Ronge District (DAO). Windrum Lake north of Churchill River (CAN).

A. nudicalis L.—Wild Sarsaparilla. Common in rich woods; widely distributed.

UMBELLIFERAE (Ammiaceae)—Parsley Family

**Carum carvi* L.—Caraway. Frequently escaped from cultivation along roadsides.

Cicuta bulbifera L.—Bulb-bearing Water-hemlock. Frequent in marshes northward. Archerwill, McKague, Prince Albert National Park (UNS); Lake Athabaska (Raup).

C. douglasii (DC.) Coult. & Rose (*C. occidentalis* Greene).—Western Water-hemlock. Common in shallow ponds and marshes.

C. mackenzieana Raup.—Mackenzie River Water-hemlock. Frequent on margins of lakes and swamps around Lake Athabaska (Raup). Perhaps not rare in the subarctic forest south to the Churchill River, as it is known to range eastward to James Bay. See: Dutilly et al in Cont. Arctic Inst. Catholic Univ. Amer., Wash., No. 5F:98-99, 1954.

**Conium maculatum* L.—Poison Hemlock. Waste place at McClean (DAO).

Cymopteris acaulis (Pursh) Raf.—Stemless Cymopteris. Frequent on dry plains and hills. Fort Qu' Appelle, Langham, Moose Jaw, Oxbow, Saskatchewan Landing, Saskatoon, Swift Current, Mortlach.

Heracleum lanatum Michx. (*H. douglasii* DC.; *H. maximum* Bartr., *nomen subnudum*).—Cow Parsnip. Common in moist woods and alluvial river flats.

Lomatium dissectum (Nutt.) Math. & Const. var. *multifidum* (Nutt.) Math. & Const. (*Leptotaenia multifida* Nutt.).—Mountain Wild Parsnip. Moist coulee near Battle Creek Ranger Station in the Cypress Hills (DAO).

L. foeniculaceum (Nutt.) Coult. & Rose (*Cogswellia foeniculacea* (Nutt.) Coult. & Rose; *C. villosa* (Raf.) Schult.; *C. daucifolia* (Nutt.) M. E. Jones.—Hairy Parsley. Common on dry hills and prairie.

L. macrocarpum (Nutt.) Coult. & Rose (*C. macrocarpa* (Nutt.) M. E. Jones).—Large-fruited Parsley. Occasional on dry prairie hillsides. Robsart, Cypress Hills, Saskatchewan Landing, Saskatoon (UNS); Wood Mtn. (CAN); Mortlach (DAO).

L. montanum Coult. & Rose (*C. montana* (Coult. & Rose) M. E. Jones).—Mountain Parsley. West Block Cypress Hills Forest (DAS).

L. orientale Coult. & Rose (*C. orientalis* (Coult. & Rose) M. E. Jones).—White-flowered Parsley. On dry plains at Bienfait (DAO).

Musineon divaricatum (Pursh) Nutt. var. *hookeri* Torr. & Gray (*M. trachyspermum* Nutt.; *M. angustifolium* Nutt.; *M. divaricatum* of Sask. reports, not Nutt.).—Rough-seeded Musineon. Occasional on dry hills and plains. Moose Mtn., Swift Current (CAN); Langham, Lebret, Regina, Saskatoon, Lumsden, Moose Jaw, Saskatchewan Landing (UNS, DASC). See: N. Amer. Flora 28B:125, 1944.

Osmorhiza chilensis Hook. & Arn. (*O. divaricata* (Britt.) Suksd.; *O. intermedia* Rydb.; *Washingtonia divaricata* Britt.).—Western Sweet Cicely. Wooded banks in the Cypress Hills (DAO).

O. depauperata Philippi (*O. obtusa.* (Coult. & Rose) Fern.; *W. obtusa* Coult. &

Rose.)—Blunt-fruited Sweet Cicely. Scarce in moist woods. Cypress Hills, McKague (UNS, DAO).

O. longistylis (Torr.) DC. (*W. longistylis* (Torr. & Britt.); *O. claytoni* of reports from Sask. by Constance and Shan in Calif. Publ. Bot. 23: 134, 1948, and in Gray's Man., ed. 8, not C. B. Clarke).—Smooth Sweet Cicely. Frequent in rich aspen woods. Wordsworth, Katepwa, Kennedy, Swift Current, Pike Lake (UNS); Cypress Hills (DAO); Crane Lake (CAN), as *O. claytoni*.

**Pastinaca sativa* L.—Parsnip. Occasionally escaped from cultivation. Waldheim, Swift Current (UNS); McKague, Mortlach (DAO).

Perideridia gairdneri (Hook & Arn.) Mathias (*Carum gairdneri* (Hook & Arn.) A. Gray; *Atenia montana* (Blank.) Rydb.).—Gairdner's Squaw-root. A Rocky Mountain species, common in grassland on the Cypress Hills plateau. The report from "50 miles south of Battleford" by Macoun, Cat. Can. Plants, probably refers to the similar *Cicuta bulbifera*, as no specimen from that area was located in the National Herbarium of Canada.

Sanicula marylandica L.—Black Snake Root. Common in rich woods.

**Scandix pecten-veneris* L.—Shepherd's Needle. Weed at Golburn (DAS).

Sium suave Walt. (*S. cicutaefolium* of auth., not Schrank).—Water Parsnip. Common in ponds. This species resembles *Cicuta douglasii*.

Zizea aptera (A. Gray) Fern. (*Z. cordata* of auth., not Koch).—Wingless Meadow Parsnip. Common in moist meadows and low prairie.

Z. aurea (L.) Koch.—Golden Meadow Parsnip. Moist meadow at Strongfield (UNS).

CORNACEAE—Dogwood Family

Cornus alba L. ssp. *stolonifera* (Michx.) Wangerin (*C. stolonifera* Michx.; *Svida stolonifera* (Michx.) Rydb.; *S. interior* Rydb.; *S. instolonea* A. Nels.; *S. baileyi* (Coult. & Rose) Rydb.).—Red Osier Dogwood. Common in rich woods and alluvial river banks.

C. canadensis L. (*Chamaepericlymenum canadense* (L.) Aschers. & Graebn.).—Bunchberry. Abundant in coniferous woods.

PYROLACEAE—Wintergreen Family

Chimaphila umbellata (L.) Barton ssp. *cisatlantica* (Blake) Hultén (var. *cisatlantica* Blake; *C. corymbosa* Pursh).—Eastern Prince's Pine. Coniferous woods in central eastern part of our area. White Fox, Birch Lake (DAS).

C. umbellata ssp. *occidentalis* (Rydb.) Hultén (var. *occidentalis* (Rydb.) Blake; *C. occidentalis* Rydb.).—Western Prince's Pine. Cypress Hills (DAO); Lake Athabaska (Raup).

Monesis uniflora (L.) A. Gray.—One-flowered Pyrola. Frequent in coniferous woods.

Monotropa hypopithys L. ssp. **lanuginosa** (Michx.) Breitung, comb. nov. (*Monotropa lanuginosa* Michx., Fl. Bor. Amer. 1:266,1803; *Hypopithys lanuginosa* (Michx.) Nutt.; *H. latisquama* Rydb.; *M. hypopithys* var. *latisquama* (Rydb.) Kearney & Peables; *M. latisquama* (Rydb.) Hultén).—American Pine-sap. Lodgepole pine woods in the Cypress Hills (UNS, DAO). The American ssp. *lanuginosa* is distinguished from the typical European species by the smaller flowers, 10-13 rarely 15 mm long which are nodding at first but soon becoming erect, by the stem which is puberulent above and the petals are short-hairy within. There is no constant difference between eastern and western American plants. Eastern American plants are predominantly narrow-scaled, while in the western specimens the stem bracts are predominantly broader (*H. latisquama* of Rydb.) as in typical *M. hypopithys*. However, I have seen broad-scaled specimens from the east (Minnesota) and narrow-bracted plants from the west (Idaho). In China and India occurs another race with small flowers as in the American plant but differs by stem and flowers more densely and coarsely pubescent and the petals are long-hairy within. W. J. Hooker in Flora of British India 3:476, 1882, describes this Asiatic race as *Hypopithys lanuginosa* Nutt. Thus, *M. hypopithys* is circumboreal, comprised of at least three geographic races. The typical species has flowers 15-17 mm long.

M. uniflora L.—Indian Pipe. Scarce in rich deciduous woods. Big River, Emma Lake, Waskesiu Lake (UNS); Amisk Lake (DAS); Lake Athabaska (Raup).

Pterospora andromedea Nutt.—Pine Drops. Rare in lodgepole pine woods in the Cypress Hills (UNS, DAO).

Pyrola asarifolia Michx.—Pink-flowered Pyrola. Common in aspen woods.

P. asarifolia var. *purpurea* (Bunge) Fern. (var. *incarnata* (Fisch.) Fern.; *P. uliginosa* Torr.).—Bog Pyrola. Frequent in spruce swamps.

P. elliptica Nutt.—White-flowered Pyrola. Frequent in aspen woods.

P. grandiflora Rad.—Arctic Pyrola. Damp shore of Lake Athabaska (Raup).

P. minor L. (Braxilia minor (L.) House).—Lesser Pyrola. Scarce in damp coniferous woods and thickets. Cypress Hills (DAO, UNS); Windrum Lake (CAN); Lake Athabaska (Raup).

P. secunda L. (*Orthilia secunda* (L.) House; *Ramischia secunda* (L.) Garcke).—One-sided Pyrola. Common in mixed woods.

P. secunda var. *obtusata* Turcz.—Occasional in cool, mossy spruce woods.

P. virens Schweigger (*P. chlorantha* Sw.).—Greenish-flowered Pyrola. Occasional in coniferous woods. Cypress Hills, Beaver Creek, Emma Lake, Prince Albert, Torch River, Waskesiu Lake.

ERICACEAE—Heath Family

Andromeda polifolia L.—Bog Rosemary. Frequent in bogs northward.

Arctostaphylos alpina (L.) Spreng. ssp. *rubra* (Rehder & Wilson) Hultén (var. *rubra* Rehder & Wilson; *A. rubra* (Rehder & Wilson) Fern.; *Arctous erythrocarpa* Small).—Red Alpine Bearberry. Occasional in muskeg timber along the shore of Lake Athabaska (Raup).

A. uva-ursi (L.) Spreng. (incl. minor var. *coactilis* and *adenotrichia* Fern. & Macbr.; *Uva-ursi uva-ursi* (L.) Britt.).—Red Bearberry. Common in sandy open woodlands and rocky outcrops.

Chamaedaphne calyculata (L.) Moench (incl. vars. *angustifolia* (Ait.) Rehder and *latifolia* (Ait.) Fern.).—Leather Leaf. Occasional in swamps and bogs northward. Bannock, Crooked River, Waskesiu Lake, Lac la Ronge, Meadow Lake; Lake Athabaska (Raup).

Gaultheria hispidula (L.) Bigel. (*Chiogenes hispidula* (L.) Torr. & Gray; *Vaccinium hispidulum* L.).—Creeping Snowberry. Scarce in cool, mossy coniferous woods. McKague, Crooked River (UNS, DAO).

Kalmia polifolia Wang.—Pale Laurel. Occasional in spruce muskegs northward. Waskesiu, Crest, Crooked River, Orley, White Fox; Lake Athabaska (Raup).

Ledum groenlandicum Oeder.—Labrador Tea. Common in coniferous swamps northward.

L. palustre L. ssp. *decumbens* (Ait.) Hultén (var. *decumbens* Ait.; *L. decumbens* (Ait.) Lodd. ex Steud.).—Narrow-leaved Labrador Tea. An arctic species occurring in the extreme northern part of our area. Reeve's Lake (UNS); Lake Athabaska (Raup).

Vaccinium caespitosum Michx.—Dwarf Blueberry. Sandy pine woods. Cypress Hills, Endeavour, McKague, Meadstead, Kleczkowski.

V. myrtilloides Michx. (*V. canadense* Kalm ex Richards.; *Cyanococcus canadensis* (Richards.) Rydb.).—Canada Blueberry. Common in sandy pine woods northward.

V. oxycoccus L. (*V. microcarpum* (Turcz. ex Rupr.) Hook.; *Oxycoccus palustris* Pers.; *O. quadripetalus* Gilib.; *O. oxycoccus* (L.) MacM.).—Small Cranberry. Occasional in bogs northward. Candle Lake, Ile a la Crosse (DAO); seven miles SW of Flin Flon (DAS).

V. oxycoccus var. *ovalifolium* Michx. (var. *intermedium* A. Gray; *O. ovalifolius* (Michx.) A. E. Porsild.—Swamp Cranberry. Common in swamps and bogs northward.

V. uliginosum L.—Bog Bilberry. Muskegs and sandy ridges around Lake Athabaska (Raup).

V. vitis-idaea L. ssp. *minus* (Lodd.) Hultén (var. *minus* Lodd.; *Vitis-idaea vitis idaea* (L.) Britt.; *Vitis-idaea punctata* Moench).—Dry-ground Cranberry. Common in swamps and pine woods northward.

PRIMULACEAE—Primrose Family

Androsace occidentalis Pursh.—Western Androsace. Dry gravelly places in the southwestern part of the area. Radville (UNS); Mortlach (DAO).

A. septentrionalis L. var. *puberulenta* (Rydb.) Knuth (*A. puberulenta* Rydb.).—Puberulent Androsace. Common on dry gravelly and exposed sandy hills.

Centunculus minimus L.—Chaffweed. Damp shore of Reed Lake west of Johnstone Lake (CAN); Cory in Saskatoon district (DAO).

Dodecatheon conjugens Greene (*D. cylindrocarpum* Rydb.)—Cylindric-fruited Shooting-star. Frequent in grassland on the Cypress Hills plateau (UNS, DAO, CAN); Robsart (UNS, DASC); Simmie (DAS). See: Thompson in Cont. Dud. Herb. 4:136, 1953.

D. pulchellum (Raf.) Merr. (*D. radicatum* Greene; *D. pauciflorum* (Durand) Greene; *D. salinum* A. Nels.).—Beautiful Shooting-star. Common in moist saline meadows. See: Merrill in J. Arn. Arb. 29:212, 1948.

Glaux martima L.—Sea Milkwort. Common in wet saline meadows on prairie.

Naumburgia thyrsiflora (L.) Duby (*Lysimachia thyrsiflora* L.).—Tufted Loosetrife. Frequent in swamps; widely distributed.

Primula incana M. E. Jones.—Mealy Primrose. Frequent in moist saline meadows.

P. mistassinica Michx. (*P. maccalliana* Wieg.)—Dwarf Canadian Primrose. Wet springy places; scarce. Prince Albert (UNS); Nipawin (DAO); Amisk Lake (DAS).

Steironema ciliatum (L.) Raf. (Lysimachia ciliata L.).—Fringed Loosetrife. Common in borders of aspen woods.

S. lanceolatum (Walt.) A Gray var. *hybridum* (Michx.) A. Gray (*L. hybrida* Michx.).—Lance-leaved Loosetrife. Occasional in damp meadows in the prairie region. Watrous, Saskatoon, Humboldt (UNS); Regina (DAO).

Trientalis borealis Raf. (*T. americana* Pursh).—Star Flower. Occasional in rich pine woods northward. Hudson Bay Junction, Nipawin, Prince Albert, Waskesiu Lake Big River, Emma Lake (UNS); Lake Athabaska (Raup).

PLUMBAGINACEAE—Leadwort Family

Armeria maritima (L.) Willd. var. *interior* (Raup) Lawerence (*Statice interior* Raup).—Inland Sea-thrift. Damp places among sand dunes around Lake Athabaska (Raup).

OLEACEAE—Olive Family

Fraxinus pennsylvanica Marsh. var. *subintegerrima* (Vahl.) Fern. (var. *lanceolata* (Borkh.) Sarg.; *F. lanceolata* Borkh.; *F. viridis* Michx.f.; *F. campestris* Britt.).—Green Ash. Occasional on stream banks in S. Sask.

GENTIANACEAE—Gentian Family

Gentiana affinis Griseb. (*Dasystephana affinis* (Griseb.) Rydb.; *D. interrupta* (Greene) Rydb.).—Prairie Gentian. Frequent in wet prairie meadows.

G. amarella L. (*G. acuta* Michx.; *G. scopulorum* (Greene) Tidestrom; *G. strictiflora* (Rydb.) A. Nels.; *G. plebeja* Cham.; *Amarella acuta* (Michx.) Greene).—Northern Gentian. Common in moist meadows; widely distributed. A variable circumboreal species including numerous microspecies. Flowers blue.

G. amarella forma *michauxiana* Fern.—Associated with the typical species; common. Flowers creamy-white.

G. andrewsii Griseb. (*D. andrewsii* (Griseb.) Small.—Closed Blue Gentian. Moist prairie near Zenita (UNS).

G. barbata Fröl. (*G. tonsa* (Lunell) Vict.; *G. macounii* Holm.; *G. raupii* A. E. Porsild; *Anthopogon* Rydb.).—Fringed Gentian. Frequent in bogs and springy places. The name *G. barbata* ssp. *procera* (Holm.) Hultén, Fl. Alaska & Yukon, Pt. 8: 1303, should be applied only to the larger flowered race of the Great Lakes Region.

G. fremontii (Torr.) A. Nels. (*Chondrophylla fremontii* Torr.).—Moss Gentian. Moist sandy, slightly alkaline meadow along creek near Mortlach (DAO). See: Hudson in Can. Field-Nat. 65:207, 1951.

Halenia deflexa (J. E. Smith) Griseb.—Spurred Gentian. Frequent in open woods.

Lomatogonium rotatum (L.) Fries ex Nyman (*Pleurogyne rotata* (L.) Griseb.; *P. fontana* A. Nels.).—Marsh Felwort. Scarce in alkaline flats and calcarious springs. Sutherland, Vonda Lake (UNS); Chaplin, Little Arm Creek, Mortlach (DAO).

Menyanthes trifoliata L.—Buckbean. Common in bogs northward.

APOCYNACEAE—Dogbane Family

Apocynum androsaemifolium L.—Spreading Dogbane. Common in open woodlands; widely distributed. Var. *glabrum* Macoun (*A. scopulorum Greene*), a low, diffuse, very floriferous variant, occurs on dry exposed hillsides south of Elkwater Lake in the Cypress Hills, Alberta. Perhaps it occurs also on the Saskatchewan side of the Cypress Hills.

A. sibiricum Jacq. (*A. hypericifolium* Ait.; *A. salignum, A. cordigerum* Greene). Clasping-leaved Dogbane. Occasional on rocky river shores. Hudson Bay Junction, Lisieux, Riverhurst, Saskatoon, Swift Current, Trossachs (UNS); Crane Lake (CAN); Nipawin, Cypress Hills (DAO).

ASCLEPIADACEAE—Milkweed Family

Asclepias ovalifolia Decne.—Dwarf Milkweed. Frequent in thickets on banks. McKague, Chelan, Hudson Bay Junction (UNS, DAO).

A. speciosa Torr.—Showy Milkweed. Occasional on prairie across the southern part of the province. Swift Current, Tompkins, Success, Dundurn, Cypress Hills (UNS); Maple Creek (DAO).

A. viridiflora Raf. (*Acerates viridiflora* (Raf.) Eaton).—Green Milkweed. Occasional on river banks. Beaver Creek, Carlyle Lake, Mortlach, Pike Lake, Saskatoon.

A. viridiflora var. *linearis* (A. Gray) Fern. (*Acerates viridiflora* var. *linearis* A. Gray).—Linear-leaved Milkweed. Dry sandy banks; scarce. Saskatoon, Wadena (UNS).

CONVOLVULACEAE—Morning-glory Family

**Convolvulus arvensis* L. (*C. ambigens House*).—Field Bindweed. Frequent in cultivated fields and waste places.

**C. sepium* L.—Large-flowered Bindweed. Waste places and cultivated fields. Saskatoon, Nipawin (UNS). Corolla white.

C. sepium forma *coloratus* Lange (var. *americanus* Sims; var. *communis* Tryon; *C. americanus* (Sims) Greene).—American Bindweed. Frequent in thickets along streams; widely distributed. Corolla pink.

C. sepium var. *fraterniflorus* Mack. & Bush (*C. interior* House; *C. macounii* Greene). —Inland Bindweed. Occasional on dry sandy prairie. Carnduff, Valor, Val Marie, Mortlach, Assiniboia (UNS); Regina (DAO). Cypress Hills (CAN, type locality of *C. macounii*). Corolla white; plant more or less pubescent.

Cuscuta campestris Yuncker (*C. cephalanthi* of Fraser and Russell, ed 1, not Engelm.). —Prairie Dodder. On Alfalfa at Oliver about 9 miles north-west of Rosetown (UNS). Probably adventive into our area.

C. coryli Engelm.—Hazel Dodder. Coulee side near Mortlach (DAS, listed as *C. gronovii* by Hudson, l.c.). On *Solidago* and *Glycyrrhiza*.

C. umbrosa Hook. (*C. curta* (Engelm.) Rydb.; *C. megalocarpa* Rydb.; *C. gronovii* of auth., not Willd.; *C. planiflora* of Fraser and Russell, not Engelm.).—Short-capsuled Dodder. Occasional in moist ground and river valleys. Nipawin, Runciman (UNS, DAO); Saskatoon (UNS); Carnduff (DASC, DAO); Cypress Hills (CAN); Swift Current (DASC); Mortlach (DAS). On *Humulus, Glycyrrhiza, Salix, Solidago,* etc.

POLEMONIACEAE—Phlox Family

Collomia linearis Nutt. (*Gilia linearis* (Nutt.) A. Gray).—Narrow-leaved Collomia. Common on prairie.

Linanthus septentrionalis H. L. Mason (*L. harknesii* (Curran) Greene var. *septentrionalis* (H. L. Mason) Jepson & Bailey).—Northern Linanthus. Open hillsides. Nashlyn (UNS, DAO); Cypress Hills (CAN).

Navarretia minima Nutt.—Least Navarretia. Occasional in moist depressions on prairie. Maple Creek, Moose Jaw, Ravenscrag, Swift Current (UNS); Val Marie (UNS, DASC); Cypress Hills (DAO, DAS); Mortlach (DAO); Crane Lake (CAN).

Phlox alyssifolia Greene.—Blue Phlox. Twelve-mile Creek near Wood Mountain (CAN); Bengough (DAS); Rockglen (DAS).

P. hoodii Richards.—Moss Phlox. Common on dry prairie and hills.

HYDROPHYLLACEAE—Waterleaf Family

Ellisea nyctelea L. (*Macrocalyx nyctelea* (L.) Kuntze; *Nyctelea nyctelea* (L.) Britt.). —Nyctelea. Occasional on wooded banks. Cypress Hills, Langham, Oxbow, Qu'Appelle, Saskatoon, Wordsworth, Mortlach.

Phacelia franklinii (A. Br.) A. Gray.—Franklin's Phacelia. Occasional in sandy pine woods northward. Hudson Bay Junction, Nipawin, Prince Albert, Waskesiu Lake (UNS); Candle Lake (DAO); Lake Athabaska (Raup).

P. thermalis Greene (*P. glandulifera* of Sask. reports, not Piper).—Hot Springs Phacelia. Ditch bank near Val Marie (DASC). Probably adventive from west of the Rocky Mountains.

BORAGINACEAE—Borage Family

**Amsinkia barbata* Greene (*A. idahoensis* M. E. Jones).—Fiddle-neck. Waste place near grain elevator at Estevan (DAS).

**Borago officinalis* L.—Borage. Waste place at Delisle (UNS).

Cryptantha fendleri (A. Gray) Greene (*C. minima* Rydb.; *C. crassisepala, C. kelseyana* and *C. leiocarpa* of Sask. reports, not Greene).—Fendler's Cryptanthe. Frequent on dry prairie in the southwestern part of the area. Swift Current, Leinan, Webb (UNS, DASC). Crane Lake, Moose Jaw (CAN); Mortlach (DAO).

C. macounii (Eastw.) Payson (*Oreocarya macounii* Eastw.; *O. glomerata* and *O. apera* of reports from Sask., not Pursh, or Eastw.).—Macoun's Oreocarya. Frequent on dry hills and plains. Type locality: Moose Mtn. Creek, *E. Bourgeau* in 1858 (GH). Cypress Hills (DAO, as *C. crassisepala*).

**Cynoglossum officinale* L.—Hound's Tongue. Waste places. Alameda, Wolsely (UNS).

**Echium vulgare* L.—Blue-weed. Waste place near Regina (UNS).

Hackelia deflexa (Wahl.) Opiz var. *americana* (A. Gray) Fern. & Jtn. (*H. americana* (A. Gray) Fern.; *Lappula deflexa* (Wahl.) Garcke var. *americana* (A. Gray) Greene; *L. americana* (A. Gray) Rydb.).—American Nodding Blue-bur. Occasional on wooded banks. Cypress Hills (DAO); Saskatoon, Pike Lake, Beinfait (UNS).

H. floribunda (Lehm.) Jtn. (*Lappula floribunda* (Lehm.) Greene).—Many-flowered Blue-bur. Occasional on wooded banks in SW Saskatchewan. Cypress Hills, Mortlach (DAO); Langham, Saskatoon, Maple Creek, Swift Current (UNS).

Heliotropium curassavicum L. var. *obovatum* A. DC. (*H. spathulatum* Rydb.).—Spatulate-leaved Heliotrope. Frequent around saline lakes in SW Saskatchewan.

**Lappula echinata* Gilib. (*L. myosotis* Moench; *L. lappula* (L.) Karst.).—Blue-bur. Common weed in fields and waste places.

L. redowskii (Hornem.) Greene var. *occidentalis* (S. Wats.) Rydb. (*L. fremontii* of Sask. reports, not Greene).—Western Blue-bur. Occasional on sandy banks and plains. Elbow, Dundurn, Humboldt, Pilot Butte, Saskatoon, Swift Current, Tomkins, (UNS); Mortlach DAO); Crane Lake, Macoun 5807 (CAN, as *L. fremontii*).

Lithospermum canescens (Michx.) Lehm.—Hoary Puccoon. Common around aspen groves and moist prairie, westward to about the central part of the area.

L. incisum Lehm. (*L. linearifolium* Goldie; *L. mandanense* Spreng; *L. angustifolium* Michx., not Forsk.).—Narrow-leaved Puccoon. Frequent on dry prairie.

L. ruderale Lehm.—Wooly Cromwell. Grassy slope on the Cypress Hills near Battle Creek Ranger Station (DAO, DAS, DASC).

**Lycopsis arvensis* L.—Small Bugloss. In fields and waste places. Indian Head, Kildeer (UNS).

Mertensia lanceolata (Pursh) DC. (*M. linearis Greene*).—Lance-leaved Lungwort. Scarce in thickets. Manoka, Hitchcock, Chaplin, Dundurn.

M. paniculata (Ait.) G. Don (*M. pilosa* (Cham.) DC.).—Tall Lungwort. Common in woods northward.

**Myosotis arvense* (L.) Hill.—Forget-me-not. In field near Bjorkdale (DAO, UNS).

Onosmodium molle Michx. var. *occidentalis* (Mack.) Jtn. (*O. occidentale* Mack.).—Western False Cromwell. Thicket on bank; rare. Carnduff (DAO, DASC).

Plagiobothrys scopulorum (Greene) Jtn. (*Allocarya scopulorum* Greene; *A. californica* of Rydbs. manuals, not Greene).—Rock Popcorn Flower. Occasional around

ponds in the prairie region. Cypress Hills (DAO); Trossachs, Unity, Maple Creek, Swift Current, Saskatoon, Radville (UNS).

VERBENACEAE—Vervian Family

Verbena bracteata Lag. & Rodr. (*V. bracteosa* Michx.).—Carpet Vervian. Occasional on dry sandy prairie. Climax, Carlyle, Belbeck, Arcola, Forget, Moose Jaw, Twelve-mile Lake.

V. hastata L.—Blue Vervian. Moist prairie. Wadena (DAS).

V. urticifolia L.—White Vervian. Rich thickets. Gainsborough (DAS).

LABIATAE (Lamiaceae)—Mint Family

Agastache foeniculum (Pursh) Ktze. (*A. anethiodora* (Nutt.) Britt.).—Fragrant Giant Hyssop. Common in wooded areas northward.

Dracocephalum nuttallii Britt. (*Physostegia parviflora* Nutt. ex Benth., not *Dracocephalum parviflorum* Nutt.; *Physostegia ledinghamii* Boivin.).—Western Dragonhead. Frequent along streams across the southern part of the area. Pike Lake, Beaver Creek, Indian Head (UNS, DAS); Tisdale, Eldersley, Tantallon (DAO).

**Galeopsis tetrahit* L.—Hemp Nettle. Occasional in waste places. McKague, Orley, Tisdale, Conquest, Stenan, St. Gregor, Wadena, Waskesiu Lake.

**Glechoma hederacea* L. (*Nepeta hederacea* (L.) Trevisan).—Creeping Charlie. Occasional in lawns, hedges and abandoned farmsteads, McKague (UNS, DAO).

Hedeoma hispida Pursh.—Rough Pennyroyal. Occasional on dry sandy prairie and rocky banks. Bengough, Canfield, Consul, Estevan, Wood River, Elbow.

**Hyssopis officinalis* L.—Hyssop. Roadside through hilly prairie west of Carmel (DAO).

**Lamium album* L. White Dead Nettle. Weed in garden at Spears (UNS).

**L. amplexicaule* L. Clasping Henbit. Cultivated fields and waste places. Tisdale, Kamsack, Marshall (UNS); Medstead, Melfort (DAO).

**Leonurus cardiaca* L.—Common Motherwort. Waste places. Gainsborough (DAS).

Lycopus americanus Muhl. ex Bart.—Cut-leaved Water-horehound. Occasional in moist meadows. Wadena, Saskatoon, Pike Lake, Indian Head (UNS); McKague, Cypress Hills (DAO).

L. lucidulus Turcz. ex Benth. var. *americanus* A. Gray (*L. asper* Greene).—Western Water-horehound. Common in wet sedge meadows.

L. uniflorus Michx.—Northern Water-horehound. Wet shaded banks. Big River (UNS); McKague, Nipawin (DAO).

Mentha arvensis L. var. *glabrata* (Benth.) Fern. (*M. canadensis* L. var. *glabrior* Hook.; *M. canadensis* var. *glabrata* Benth.; *M. glabrior* (Benth.) Rydb.; *M. rubella* Rydb.).—Glabrate Mint. Widespread and common in sedge meadows.

M. arvensis var. *penardi* Briq (*M. penardi* (Briq.) Rydb.).—Thick-leaved Mint. Frequent in moist meadows of the prairie region.

**M. spicata* L.—Spearmint. Cultivated and sometimes escaped. Bjorkdale (DAS).

Moldavica parviflora (Nutt.) Britt. (*Dracocephalum parviflorum* Nutt.).—American Dragonhead. Rocky woods, becoming especially common in clearings and burnt-over woods; also a noxious weed in alfalfa fields. Cypress Hills, Macdowall, Saskatoon (UNS); Prince Albert, Battleford (CAN); McKague, Maple Creek (DAO).

**M. thymiflora* (L.) Rydb. (*D. thymiflorum* L.).—Slender Dragonhead. Fields and waste places. Lebret, Katepwa (UNS, DAS).

Monarda fistulosa L. var. *menthaefolia* (Graham) Fern. (*M. menthaefolia* Graham). —Wild Bergamot. Common on prairie, in thickets and borders of woods. Not readily distinguished from var. *mollis* (L.) Benth., and, perhaps best included with it.

**Nepeta cataria* L.—Catnip. Weed along roadsides and in vacant lots. Carnduff, Gainsborough (DAS).

Salvia reflexa Hornem. (*S. lanceolata* Willd.; *S. lanceaefolia* of Amer. auth., not Poir.).—Western Wild Sage. On dry prairie near Moosomin (DAS, DAO).

Scutellaria galericulata L. (*S. epilobiifolia* A. Hamilt.).—Marsh Skulcap. Frequent in swamps and along streams. After studying American and European material in the National Herbarium of Canada, the writer is inclined to agree with Hultén, Fl. Alaska

& Yukon, pt. 9:1363, 1948, that there is no constant difference between the Old and the New World plant, not as a geographic race, nor even as a variety.

S. lateriflora L.—Blue Skullcap. Damp meadow near Trossachs (UNS).

Stachys palustris L. ssp. *pilosa* (Nutt.) Epling (var. *pilosa* (Nutt.) Fern.; var. *nipigonensis* Jenn.; *S. scopulorum* Greene; *S. borealis* Rydb.).—Marsh Hedge Nettle. Common in damp meadows and along streams.

Teucrium canadense L. var. *occidentale* (A. Gray) McClintock & Epling (*T. occidentale* A. Gray; *T. boreale* Bickn.).—Hairy Germander. In damp soil. Yorkton (UNS); Lumsden (DAS).

SOLANACEAE—Potato Family

**Datura stramonium* L.—Thorn Apple. Occasional as a weed; poisonous. Melfort, Senlac, Shellbrook (UNS).

**Hyposcyamus* niger L.—Black Henbane. Occasional along roadsides and in waste places. Cudworth, Macklin, Saltcoats, Saskatoon, Southey.

Physalis grandiflora Hook. (*Chamaesarachia grandiflora* (Hook.) Fern.; *Leucophysalis grandiflora* (Hook.) Rydb.)—Large White-flowered Ground-cherry. Occasional in sandy pine woods northward. Nipawin, Codette, Love, Prince Albert, Meadow Lake, Ila a la Crosse (UNS).

**Solanum nigrum* L.—Black Nightshade. Frequently grown in gardens. Occasional in woods and thickets where it appears indigenous, probably from seeds distributed by birds. Our plant may possibly be segregated as the scarcely distinct *S. americanum* Mill. (*S. interius* Rydb.).

**S. rostratum* Dunal (*Androsera rostrata* (Dunal) Rydb.).—Sand-bur, Buffalo bur. Occasional as a weed. Swift Current (DASC); Pelly (DAS). Probably introduced from plains south of the border; not established.

S. triflorum Nutt.—Wild Tomato. Frequent in disturbed prairie, around gopher holes and a weed in cultivated fields.

SCROPHULARIACEAE—Figwort Family

Besseya cinerea (Raf.) Pennell (*B. wyomingensis* (A. Nels.) Rydb.; *Synthyris gymnocarpa* (A. Nels.) Heller).—Kitten-tails. In fescue grassland on top bench of the Cypress Hills (UNS, DAO). According to Pennell, Proc. Acad. Nat. Sci. Philad. 85:77-106, 1933, the related *Besseya rubra* is more western, found only west of the Rocky Mountains.

Castilleja coccinea (L.) Spreng.—Scarlet Paint-brush. Damp meadow. Buchanan (UNS).

C. miniata Dougl. ex Hook. (*C. rhexifolia* of Sask. reports, not Rydb.).—Red Indian Paint-brush. Frequent in wooded areas. *C. rhexifolia* is a distinct species occurring in the subalpine zone of the Rocky Mountains.

C. pallida (L.) Knuth ssp. *septentrionalis* (Lindl.) Pennell (var. *septentrionalis* (Lindl.) A. Gray; *C. acuminata* of E. Amer. auth., not Spreng.; *C. raupii* Pennell).—Northern Paint-brush. Frequent in upland woods and sandy shores of Lake Athabaska (Raup).

C. sessiliflora Pursh.—Downy Paint-brush. Occasional on dry prairie. Fort Qu'Appelle, Katepwa, Indian Head, Cypress Hills.

**Chaenorrhinum minus* (L.) Lange (*Linaria minor* (L.) Desf.).—Small Snap-dragon. Around grain elevators and railway cinders. Gillespie, Prudhomme, Swift Current (UNS).

Collinsia parviflora Dougl. ex Lindl.—Blue-lips. Dry semi-wooded hillsides. Carlyle, Cypress Hills (UNS, DAO); Little Birch Lake (DAS).

Euphrasia arctica Lange (*E. disjuncta, E. hudsoniana* Fern. & Wieg.; *E. subarctica* Raup).—Eyebright. Damp crevices on shore of Lake Athabaska (Raup).

Gratiola neglecta Torr. (*G. virginiana* of auth., not L.).—Clammy Hedge-hyssop. Frequent on muddy spots on prairie.

Limosella aquatica L.—Mudwort. Occasional on alkaline shores of lakes and ponds. Alameda, Elbow, Fife Lake, Leacross, Saskatoon, Val Marie.

**Linaria canadensis* (L.) Dumont var. *texana* (Scheele) Pennell (*L. texana* Scheele).—Blue Toad-flax. Alsask (UNS). Probably adventive with garden seed.

**L. dalmatica* (L.) Mill.—Dalmatian Toad-flax. Escaped from cultivation in the prairie region.

**L. vulgaris* Hill.—Butter-and-eggs. Frequent in fields, roadsides and waste places.

Melampyrum lineare Desr.—Cow Wheat. Occasional in sandy pine woods northward. Nipawin, Prince Albert (UNS, DAO); Lake Athabaska (Raup).

Mimulus glabratus HBK. var. *fremontii* (Benth.) Grant (*M. jamesii* Torr. & Gray var. *fremontii* Benth.; *M. geyeri* Torr.).—Small Yellow Monkey-flower. Springy place in the Qu'Appelle valley near Whitewood (DAS, DAO).

M. guttatus Fischer ex DC. (*M. langsdorfii* Donn).—Large Yellow Monkey-flower. Along brooks in the Cypress Hills (UNS, DAO, DASC).

M. ringens L.—Blue Monkey-flower. Gravelly shore of the Red Deer River near Hudson Bay Junction (DAO). For "A Monograph of the Genus Mimulus" see: Grant in Ann. Mo. Bot. Gard. 11:99-388, 1924.

Orthocarpus luteus Nutt.—Owl's Clover. Common on dry prairie.

Pedicularis groenlandica Retz. (*Elephantella groenlandica* (Retz.) Rydb.).—Elephant Heads. Occasional in bogs northward. Cameo, Edam, Turtleford, Prince Albert National Park (UNS).

P. parviflora J. E. Smith (*P. palustris* L. var. *wlassoviana* Bunge).—Purple Lousewort. Occasional in bogs northward. McKague, Candle Lake, Prince Albert; Lake Athabaska (Raup).

Penstemon albidus Nutt.—White-flowered Beard-tongue. Occasional on dry prairie and plain. Indian Head, Maple Creek, Swift Current (UNS, DASC).

P. confertus Dougl.—Yellow Beard-tongue. Along railway tracks near Swift Current (UNS, DAO, DASC). Probably introduced from the foothills in western Alberta, where it is common.

P. erianthera Pursh (*P. cristatus* Nutt.; *P. puberulentus* Rydb.).—Crested Beard-tongue. Eroded hillside near Estevan (UNS).

P. gracilis Nutt.—Lilac-flowered Beard-tongue. Frequent on moist prairie.

P. nitidus Dougl.—Blue Beard- tongue. Frequent on dry prairie and exposed hills.

P. procerus Dougl. ex Graham.—Slender Beard-tongue. Common on moist prairie.

Rhinanthus crista-galli L. (*R. kyrolae, R. rigidus* Chab.).—Yellow Rattle. Occasional in edge of woods and open banks. Carnduff (UNS); Cypress Hills, Ile a la Crosse (DAO).

Scrophularia lanceolata Pursh (*S. occidentalis* (Rydb.) Bickn.).—Lanceolate Figwort. Along abandoned railway grade at Mortlach (DAO, DAS, DASC).

Veronica americana (Raf.) Schw.—American Speedwell. Frequent in shallow water and springy places. Bjorkdale, Pre Ste Marie, Tisdale, Waskesiu Lake, Pike Lake, Cypress Hills.

**V. longifolia* L.—Long-leaved Speedwell. Along roadside on prairie. Raymore (UNS).

V. peregrina L. var. *xalapensis* (HBK.) St. John. & Warren (ssp. *xalapensis* (HBK.) Pennell; *V. xalapensis* HBK.).—Hairy Speedwell. Frequent in wet places.

**V. persica Poir.*—Bird's Eye. An annual garden weed. Swift Current (DASC).

V. salina Schur (*V. comosa* Richter; *V. catenata* Pennell; *V. connata* Pennell, not Raf.).—Water Speedwell. Occasional along watercourses. Hudson Bay Junction (UNS); Maple Creek, Cypress Hills, Indian Head (DAO).

V. scutellata L.—Marsh Speedwell. Frequent in moist meadows.

V. serpyllifolia L. var. *humifusa* (Dickson) Vahl (*V. humifusa* Dickson; *V. tenella* Allioni; *V. serpyllifolia* var. *borealis* Laestad.).—Northern Thyme-leaved Speedwell. Scarce in springy places. Cypress Hills (UNS, DAO, DAS).

LENTIBULARIACEAE—Bladderwort Family

Pinguicula villosa L.—Hairy Bladderwort. Mossy hummocks in muskeg at Lake Athabaska (Raup).

P. vulgaris L.—Butterwort. Calcarious bog near Prince Albert (UNS, DAO).

Utricularia intermedia Hayne.—Flat-leaved Bladderwort. Occasional in shallow pools and bogs. Dahlton, Pike Lake, Prince Albert, Nipawin.

U. minor L.—Lesser Bladderwort. Rare in bogs and quiet ponds in the forested region. Dahlton, Nipawin (UNS, DAO); Lake Athabaska (Raup).

U. vulgaris L. var. *americana* A. Gray (*U. macrorrhiza Le Conte*).—Greater Bladderwort. Frequent in shallow lakes and sluggish streams.

OROBANCHACEAE—Broom-rape Family

Orobanche fasciculata Nutt. (*Anoplanthus fasciculatus* (Nutt.) Walp.; *Thalesia fasciculata* (Nutt.) Britt.).—Cancer-root. Occasional on dry plains. Spy Hill, Mortlach, Cypress Hills, Bracken, Saskatoon, Swift Current.

O. ludoviciana Nutt. (*Myzorrhiza ludoviciana* (Nutt.) Rydb.).—Broom-rape. Occasional on dry sandy hills and plains. Beaver Creek, Pike Lake, Regina, Sutherland, Wakaw, Cypress Hills, Little Manito Lake, Mortlach.

PLANTAGINACEAE—Plantain Family

Plantago elongata Pursh (*P. pusilla* of Macoun, Cat. Can. Plants, and of Fraser and Russell, not Nutt.).—Linear-leaved Plantain. Occasional in alkaline meadows. Moose Jaw, Val Marie, Kindersley, Herbert (UNS); Cypress Hills (CAN).

P. eriopoda Torr. (*P. rugelii* of Fraser and Russell, in part, not Decne).—Saline Plantain. Common in moist saline meadows on prairie. Weyburn, Maple Creek (UNS, as *P. rugelii*).

**P. lanceolata* L.—English Plantain. Weskesiu Lake (UNS).

**P. major* L.—Common Plantain. Abundant in dooryards, along roadsides, etc.

P. major var *asiatica* (L.) Decne. (var. *pilgeri* Domin; *P. rugelii* of Fraser and Russell, in part, not Decne.).—Meadows and shores. Hudson Bay Junction, Nipawin, Vonda Lake, Beaver Flats, Leash (UNS, DAS); Saskatchewan Landing (UNS, as *P. rugelii*).

P. purshii Roem. & Schult.—Pursh's Plantain. Occasional on dry prairie and plain. Cypress Hills, Scull Creek, Clearfield, Elbow, Saskatchewan Landing.

P. spinulosa Decne. ex DC. (*P. aristata* of Fraser and Russell, not Michx.).—Spinulose-bracted Plantain. Scarce on dry prairie. Madge Lake, Regina (UNS); Bear Hills south of Biggar and Bad Hills south of Rosetown (CAN).

RUBIACEAE—Madder Family

**Galium aparine* L.—Cleavers. Kelvington (UNS). "Found in grain grown from seed imported from England" Fraser and Russell.

G. aparine var. *vaillantii* (DC.) W. G. J. Koch (*G. vaillantii* DC.; *G. spurium* L.).—Vaillant's Cleavers. Occasional in rich woods and thickets. Swift Current, Maple Creek, Beaver Creek, Trossachs, Mortlach.

G. boreale L.—Northern Bedstraw. Common on moist prairie and in open woods.

G. labradoricum Wieg.—Labrador Bedstraw. Occasional in bogs. Archerwill, Ituna, McKague, Pike Lake, Ile a la Crosse, Lac la Ronge.

G. trifidum L.—Small Bedstraw. Swamps and wet shores; occasional. Cypress Hills, McKague, Invermy, Pike Lake, Yorkton.

G. triflorum Michx. (*G. asprellum* of Fraser & Russell, ed 3, not Michx.).—Sweet-scented Bedstraw. Frequent in woods.

Houstonia longifolia Gaertn.—Long-leaved Bluets. Occasional on dry gravelly openings in the parkland. McKague, Prince Albert, Wordsworth, Meadow Lake, Ituna, Macdowall, St. Laurent.

CAPRIFOLIACEAE—Honeysuckle Family

Diervilla lonicera Mill. (*D. diervilla* (L.) MacM.).—Bush Honeysuckle. Scarce in dry pine woods northward. Bjorkdale, Nipawin (UNS, DAO).

Linnaea borealis L. ssp. *americana* (Forbes) Hultén ex R. T. Clausen (var. *americana* (Forbes) Rehder; *L. americana* Forbes).—Twin-flower. Common in coniferous woods.

Lonicera caerulea L. var. *villosa* (Michx.) Torr & Gray (*L. villosa* (Michx.) Roem & Schult.; *Xylosteon villosum* Michx.).—Blue Fly-honeysuckle. Occasional in swamps northward. McKague, Prince Albert, Sikip, Meadow Lake, Wierdale. Plant variable in degree of pubescence.

L. dioica L. var. *glaucescens* (Rydb.) Butters (*L. glaucescens* Rydb.).—Twining Honeysuckle. Frequent in woods; widely distributed.

L. involucrata (Richards.) Banks (*Distegia involucrata* (Richards.) Cockerell).—Involucrate Honeysuckle. Frequent in rich moist woods northward.

L. oblongifolia (Goldie) Hook. (*X. oblongifolium* Goldie).—Swamp Fly-honeysuckle. Occasional in swamps. Bodmin, Lac Vert, Pleasantdale, Wallwort, McElhanney, Sikip, White Fox.

**L. tatarica* L. (*X. tataricum* (L.) Medic.).—Tartarian Honeysuckle. A common ornamental shrub occasionally escaped from cultivation. Tisdale, Nipawin, Rosthern, Saskatoon, Swift Current, Mortlach.

Sambucus racemosa L. ssp. *pubens* (Michx.) Hulten (var. *pubens* (Michx.) S. Wats., *S. pubens* Michx.).—Red-berried Elder. Valley of the Saskatchewan River 60 miles northeast of Nipawin (DAO).

Symphoricarpos albus (L.) Blake (*S. racemosus* Michx.; *S. pauciflorus* (Robbins.) Britt.; *Xylosteon canadense* of Fraser and Russell, ed 3, not Duham).—Snow-berry. Common in wooded areas. Snowden (DAS, as *Xylosteon canadense*).

S. occidentalis Hook.—Western Snow-berry. Common on low prairie, around aspen groves and in river valleys.

Viburnum edule (Michx.) Raf. (*V. eradiatum* (Oakes) House; *V. pauciflorum* Pylaie).—Low-bush Cranberry. Frequent in woods.

V. lentago L.—Nanny-berry. On moist wooded banks in the southeastern corner of the area. Gainsborough (UNS); Wapella (DAO).

V. opulus L. ssp. *trilobum* (Marsh.) R. T. Clausen (*V. trilobum* Marsh.; *V. opulus* var. *americanum* Ait.; *V. americanum* of auth., not Mill.).—High-bush cranberry. Common in rich moist forest of the mixed wood section.

SANTALACEAE—Sandalwood Family

Comandra livida Richards. (*Geocaulon lividum* (Richards.) Fern.).—Northern Comandra. Occasional in moist spruce forest. McKague, Lake Athabaska, Emma Lake, Prince Albert, Turtle Lake, Waskesiu Lake.

C. umbellata (L.) Nutt. var. *pallida* (A. DC.) M. E. Jones (*C. pallida* A. DC.; *C. umbellata* [*C. richardsoniana* Fern.] of western reports, not Nutt.).—Pale Comandra. Common on prairie and sandy hills through the forested region.

ADOXACEAE—Moschatel Family

Adoxa moschatellina L.—Wet alder woods at Candle Lake (DAO).

LORANTHACEAE—Mistletoe Family

Arceuthobium americanum Nutt. ex Engelm. (*Razoumofskya americana* (Nutt.) Kuntze).—Pine Mistletoe. Occasional. A small fleshy parasitic plant causing large "witches brooms" to form on jack pine (*Pinus banksiana*). Prince Albert, Crutwell, Shellbrook, St. Wallburg (UNS); Meadow Lake, Beauval (DAO).

CUCURBITACEAE—Gourd Family

Echinocystis lobata (Michx.) Torr. & Gray (*Micrampelis lobata* (Michx.) Greene).—Wild Cucumber Vine. Occasional in rich soil along streams, climbing over bushes. Tisdale, Coderre, Trossachs.

CAMPANULACEAE—Bellflower Family

Campanula aparinoides Pursh var. *uliginosa* (Rydb.) Gleason (*C. uliginosa* Rydb.).—Marsh Bellflower. Occasional in wet sedge meadows. McKague, Crooked River, Montreal Lake, Prince Albert National Park, White Fox.

C. rotundifolia L. var. *petiolata* (A. DC.) J. K. Henry (*C. petiolata* A. DC).—Bluebell. Common on dry prairie and open hillsides through the forested region.

LOBELIACEAE—Lobelia Family

Downingia laeta (Greene) Greene (*Bolelia laeta* Greene).—Downingia. Collected in Crane Lake and Skull Creek by John Macoun (CAN). See: Porsild in Can. Field-Nat. 54:69, 1940; McVough in Bull. Torr. Bot. Club 19:1-57, 1941.

Lobelia dortmanna L.—Water Lobelia. Windrum Lake north of the Churchill River appr. lat. 56°02'N; Long. 104°W (CAN).

L. kalmii L. (*L. strictiflora* (Rydb.) Lunell).—Bog Lobelia. Frequent in bogs.

L. spicata Lam. var. *hirtella* A. Gray (*L. hirtella* (A. Gray) Greene).—Spiked Lobelia. Frequent in moist prairie.

VALERIANACEAE—Valerian Family

Valeriana dioica L. ssp. *sylvatica* (Sol. ex Richards.) F. G. Mey. (*V. dioica* var. *sylvatica* (Sol.) A. Gray; *V. septentrionalis* Rydb.).—Northern Valerian. Frequent in moist swampy thickets northward. McKague, Silver Park, St. Brieux, Shellbrook, Prince Albert, Prince Albert National Park, Emma Lake, Bjorkdale. See: F. G. Meyer in Ann. Mo. Bot. Gard. 38:417-19, 1951.

DIPSACACEAE—Teasel Family

Knautia arvensis (L.) Duby (*Scabiosa arvensis* L.).—Blue Buttons. Weed in dry pastures and fields. Shellbrook, Rosthern (DAS).

COMPOSITAE—Composite Family

AMBROSIINAE—Ragweed subfamily

**Ambrosia artemisiifolia* L. (*A. elatior* L.; *A. diversifolia* (Piper) Rydb.).—Common Ragweed. Frequent along roadsides and waste places. Carnduff, Maple Creek, Matador, Regina, Roche Percée, Swift Current.

A. psilostachya DC. (*A. coronipifolia* Torr. & Gray).—Perennial Ragweed. Frequent on moist prairie.

A. trifida L. (*A. striata, A. variabilis* Rydb.).—Great Ragweed. Occasional in rich soil along roadsides and in waste places. Aberdeen, Dundurn, Humboldt, Roche Percée, Saskatoon (UNS); Cypress Hills (CAN).

Franseria acanthocarpa (Hook.) Cov. (*Gaertneria acanthocarpa* (Hook.) Britt.).—Franseria. Scarce on very sandy soil in the southwestern part of the area. Beverly, Piapot, Beaver Creek, Great Sand Hills, Mortlach.

Iva axillaris Pursh.—Poverty Weed. Frequent in saline soil on prairie and occasionally persistent as a weed in cultivated fields.

I. xanthifolia Nutt. (*Cyclachaena xanthifolia* (Nutt.) Fresen.).—False Ragweed. Occasional in waste places and on stream banks. Cypress Hills (DAO); Bankend, Elbow, Saskatoon, Swift Current, Weyburn, Whitewood (DAO).

**Xanthium spinosum* L.—Spiny Cocklebur. Waste place. Steelman (UNS).

X. strumarium L. var. *canadense* (Mill.) Torr. & Gray (*X. echinatum* Murr.; *X. italicum* Moretti; *X. commune, X. macounii* Britt.; *X. glanduliferum, X. varians* Greene).—Hairy-body Cocklebur. Frequent on shores of lakes and rivers and in waste places.

X. strumarium var. *glabratum* (DC.). Cronq. (*X. glabratum* (DC.) Britt.; *X. chinense* Mill.; *X. americanum* Walt.).—Smooth-body Cocklebur. Damp slough margin. Burnham (DASC).

TUBULIFLORAE—Thistle Subfamily

Achillea millefolium L. ssp. **borealis** (Bong.) Breitung, stat. nov. (*A. borealis* Bong., Mem. Acad. Imp. Sci. St. Petersb. IV. Math. 2:149, 1832; *A. millefolium* var. *borealis* (Bong.) Farwell; var. *nigrescens* E. Mey.—Northern Yarrow. Rocky and sandy shores and ridges around Lake Athabaska (Raup, UNS). Perhaps not rare on Precambrian outcrops across the north as it occurs at Flin Flon, Manitoba (DAS).

A. millefolium ssp. *lanulosa* (Nutt.) Piper (*A. lanulosa* Nutt.).—Wooly Yarrow. Common on prairie, in meadows and clearings. In the more humid wooded sections

the plant is less villous closely resembling typical *A. millefolium* which is introduced from Europe into eastern N. America. I have not seen authentic specimens of the typical species from our area.

A. millefolium ssp. *lanulosa* var. *megacephala* (Raup) Boivin (*A. megacephala* Raup, J. Arn. Arb. 17:306, 1936; *A. millefolium* ssp. *pallidotegula* Boivin var. *megacephala* (Raup) Boivin).— Shifting sand dunes at William Point on Lake Athabaska (Raup). In addition to the above locality, this variety has also been collected in Banff National Park, Alberta (DAO).

A. millefolium ssp. **lanulosa** forma **roseoides** Breitung, forma nova.—*Liguilis roseis.* Plants with pink ligules were collected at Pre Ste. Marie and in the Cypress Hills (DAO).

A. sibirica Ledeb. (*A. multiflora* Hook.).—Siberian Yarrow. Frequent in moist sedge meadows and in river valleys. McKague, Tisdale, White Fox, Waskesiu Lake, Prince Albert, Sutherland, Pike Lake, Naicam, Margo, Annaheim, Lestock.

Anaphalis margaritacea (L.) Benth. & Hook. var. *subalpina* A. Gray (*A. subalpina* (A. Gray) Rydb.).—Pearly Everlasting. Scarce in open woods and on dry banks. Cypress Hills (DAO); Cutnife (UNS).

Antennaria anaphaloides Rydb.—Anaphalis-like Pussy-toes. Occasional in fescue grassland on the Cypress Hills plateau (DAO, UNS).

A. corymbosa E. Nels.—Corymbose Pussy-toes. Moist open woods. Cypress Hills (DAO, UNS, CAN).

A. neglecta Greene (*A. campestris* Rydb.; *A. lunellii, A. athabascensis* Greene; *A. petaloides* Fern.; *A. canadensis* of reports from Sask., not Greene; *A. racemosa* of Fraser & Russell, ed. 3., not Hook.).—Prairie Pussy-toes. Frequent on prairie and in wooded areas northward. Cypress Hills, Bruno, Canora, Crooked River, McKague, St. Gregor (UNS, DAO); Weskesiu Lake (DAS as *A. racemosa*).

A. neglecta var. *attenuata* (Fern.) Cronq. (*A. neodioica* Greene; *A. brainerdii* Fern.; *A. obovata* E. Nels.).—Tomentose Pussy-paws. Wooded slopes in the Cypress Hills (UNS, DAO, CAN).

A. neglecta var. *howellii* (Greene) Cronq. (*A. howellii* Greene).—Howell's Pussy-toes. Occasional in dry pine woods. Cypress Hills, Prince Albert, Prince Albert National Park (UNS, DAO); Windrum Lake north of the Churchill River (CAN).

A. parviflora Nutt. (*A. aprica* Greene; *A. minuscula* Boivin).—Low Pussy-toes. Frequent on dry prairie. Indian Head, Saskatoon, Senlac, Sidewood, Swift Current, Cypress Hills (UNS, DAO, DASC); Touchwood Hills (DAO, type of *A. minuscula*). Bracts variable in color from white in the common typical form to brownish in forma **brunnea** (Boivin) Breitung, trans. nov., Swift Current, Cypress Hills (DAO), and pink in forma **roseoides** (Boivin) Breitung, trans. nov. (*A. aprica* f. *brunnea* and *A. aprica* f. *roseoides* Boivin in Le Naturaliste Canadien 80:120-121, 1953). Swift Current (DAO).

A. pulcherrima (Hook.) Greene (*A. carpathica* (Wahl.) R. Br. var. *pulcherrima* Hook.).—Showy Pussy-toes. Scarce on low swampy ground. McKague, Pre Ste. Marie, Touchwood Hills (UNS, DAO); Ribstone (CAN).

A. rosea Greene (*A. dioica* (L.) Gaertn. var. *rosea* D. C. Eaton, *nomen nudum* *A. imbricata, A. concinna* A. Nels.; *A. oxyphylla* Greene).—Pink-bracted Pussy-toes. Infrequent. Saskatoon, Cypress Hills, Wallwort, Waskesiu Lake (UNS, DAO, CAN); Lake Athabaska (Raup).

A. rosea var. **nitida** (Greene) Breitung, stat. nov. (*A. nitida* Greene, Pittonia 3:283, 1898; *A. microphylla* Rydb., not Gandoger; *A. arida, A. viscidula* E. Nels.; *A. bracteosa* Rydb.).—Neat Pussy-toes. Common on prairie. *Antennaria rosea* is a highly variable apomictic species, including many ecological phases; heads nodding when young; involucral bracts varying from deep pink in the typical form to pure white in var. *nitida*. Widely distributed in western North America. On his Canadian distribution maps, Porsild, Can. Field-Nat. 64:20, pl. 3, 1950, gives an almost identical range pattern for *A. rosea* and *A. nitida*, suggesting these two phases represent but one variable species. However, observations indicate the rose-colored phase is common in the Rocky Mountains and scarce on the plains to the east, whereas the white-bracted phase is common on the plains of Alberta, Saskatchewan and Manitoba. Thus, I have proposed to distinguish the common white-bracted phase as var. *nitida* from the less common rose-bracted typical *A. rosea* present in our area.

A. umbrinella Rydb. (*A. aizoides, A. flavescens* Rydb.; *A. sedoides* Greene; *A. sub-*

viscosa Fern.).—Brown-bracted Pussy-toes. On dry gravelly slopes. Cypress Hills (UNS, DAO, CAN, type locality of *A. aizoides*); Lake Athabaska (Raup 6452, CAN, distributed as *A. nitida*, later placed in *A. subviscosa* by Porsild, Can. Field-Nat. 64:25, 1950).

**Anthemis cotula* L. (*Maruta cotula* (L.) DC.; *A. foetida* Lam.).—Fetid Camomile. Collected by Macoun 14538 at Troy in 1883 (CAN).

**A. tinctoria* L. (*Cotula tinctoria* (L.) J. Gay).—Yellow Chamomile. Roadside near Moose Jaw (DAO). Escaped from cultivation.

**Arctium minus* Schk.—Lesser Burdock. Occasional along roadsides and in waste places. Cypress Hills, Maple Creek, Big River, Francis, Regina, Tisdale.

**A. tomentosum* (Lam.) Schk.—Wooly Burdock. Weed at Rosthern (DAS).

Arnica alpina (L.) Olin ssp. *attenuata* (Greene) Maguire (*A. attenuata* Greene).—Sharp-leaved Arctic Arnica. Rocky outcrops at Lake Athabaska (UNS, DAO).

A. chamissonis Less. ssp. *foliosa* (Nutt.) Maguire (*A. foliosa* Nutt.; *A. rhizomata* A. Nels.).—Leafy Arnica. Occasional on edges of moist prairie and wet places in open woods. Cypress Hills, McKague, Tisdale, Scott, Eagle Creek, Bredenbury, Prince Albert, Breakmore, Meadow Lake.

A. cordifolia Hook.—Heart-leaved Arnica. In dry pine woods. Cypress Hills, Waskesiu Lake (UNS, DAO).

A. fulgens Pursh (*A. pedunculata* Rydb.).—Shining Arnica. Abundant in the Cypress Hills and occasional over the southern part of the prairie region.

A. lonchophylla Greene (*A. chionopappa* of Raup, l.c., 309, not Fern.).—Spear-leaved Arnica. Dry uplands northward. Meridian Creek (DAS); Lake Athabaska (Raup). Ssp. *chionopappa* (Fern.) Maguire is eastern and ssp. *arnoglossa* (Rydb.) Maguire occurs in South Dakota and NE Minnesota.

**Artemisia abrotanum* L.—Old Man Wormwood. Waste places at McKague (UNS, DAO). Escaped from cultivation.

**A. absinthium* L.—Common Wormwood. Occasional in waste places and roadsides. Golburn, Big River, Hudson Bay Junction, Macdowall, Montreal Lake, Regina.

A. biennis Willd.—Biennial Wormwood. Common in damp thickets around potholes in the prairie region.

A. campestris var. *caudata* (Michx.) Palmer & Styermark (*A. caudata* Michx.; *A. forwoodii* S. Wats.).—Tall Wormwood. Sandy pine woods northward. McKague (DAO); Prince Albert (UNS). Glabrous or somewhat pubescent biennial; involucre 2-3 mm high.

A. campestris var. *scouleriana* (Bess.) Cronq. (*A. scouleriana* (Bess.) Rydb.; *A. pacifica* Nutt.; *A. camporum* Rydb.).—Plains Wormwood. Frequent on prairie and plain. Lake Athabaska (Raup, as *A. canadensis* and *A. borealis*). More or less villous perennial; involucre 2-3 mm high. [*A. campestris* var. *borealis* (Pall.) Cronq. f. *purshii* (Bess.) Vict. & Rousseau (*A. bourgeauana* Rydb.). The type of *E. bourgeauana* was reputedly collected in "Saskatchewan 1757-9" by E. Bourgeau. However, since there are no recent collections of this plant from our area, it is presumed the Bourgeau collection actually came from the headwaters of the Saskatchewan River in the Rocky Mountains. Plant perennial; involucre 3-4 mm high].

A. cana Pursh.—Hoary Sage-bush. Frequent on dry plains in southwestern part of the area.

A. dracunculus L. (*A. dracunculoides* Pursh; *A. dracunculina* S. Wats.; *A. glauca* Pall.).—Linear-leaved Wormwood. Common on dry prairies, plains and river banks.

A. frigida Willd.—Pasture Sage. Common on dry prairie and becoming abundant following overgrazing.

A. longifolia Nutt. (*A. falcata* Rydb.).—Long-leaved Sage. Occasional on dry eroded hills and badlands in the prairie region. Cypress Hills, Estevan (DAO); Bracken, Val Marie (UNS); Old Wives Lake (CAN); Bengough (DAS, UNS, as *A. herriotii*); Yellowgrass (DASC, UNS, as *A. diversifolia*).

A. ludoviciana Nutt. var. *gnaphalodes* (Nutt.) Torr. & Gray (*A. diversifolia* Rydb.; *A. purshiana* Besser).—Prairie Sage. Common on dry prairie and plain. The type of *A. purshiana* was collected "on the plains of the Saskatchewan. Dr. Richardson. Drummond" in Hook., Fl. Bor. Amer. 1:323, 1833. For a discussion of Drummond's collections see introduction and notes under *Haplopappus uniflorus* in appended list of excluded species.

A. ludoviciana var. *pabularis* (A. Nels.) Fern. (*A. pabularis* (A. Nels.) Rydb.)—Slender Sage. Occasional on dry prairie. Swift Current, Trossachs, Meyronne, Morse, Robsart, Saskatoon (UNS); Hudson Bay Junction (UNS, DAO); Cypress Hills, North Battleford (DAO). *Artemisia ludoviciana, sens. lat.*, is a highly variable species; the above varieties are segregated provisionally. D. D. Keck, Proc. Calif. Acad. Sci. 4th ser. 25:441-2, 1946, reduces var. *gnaphalodes* and var. *pabularis* to synonymy under *A. ludoviciana.*

A. tilesii Ledeb. ssp. *unalaschensis* (Besser) Hultén (*A. tilesii* var. *elatior* Torr. & Gray; *A. hookeriana* Besser; *A. herriotii* Rydb.).—Valley of the North Saskatchewan River at North Battleford, Boivin & Breitung 6776b (DAO).

**A. vulgaris* L.—Common Mugwort. Weed in waste place near Hossier (DAO).

Aster brachyactis Blake (*A. angustus* (Lindl.) Torr. & Gray, not Nees; *Brachyactis angustus* (Lindl.) Britt.).—Rayless Aster. Frequent in moist meadows.

A. canescens Pursh (*Machaeranthera canescens* (Pursh) A. Gray).—Canescent Aster. Occasional in dry prairie in SW Sask. Val Marie, Beverley, Claydon, Kelstern, Swift Current (UNS); Cypress Hills (DAO). Bracts of involucre canescent, obscurely if at all glandular.

A. canescens var. *viscosus* (Nutt.) A. Gray (*M. viscosa* (Nutt.) Greene; *M. pulverulenta* (Nutt.) Greene).—Dry plains. Crichton, Val Marie (UNS). Involucre bracts densely glandular. This variant appears to be merely a degree of glandularity.

A. chilensis Nees ssp. *adscendens* (Lindl. ex DC.) Cronq. (*A. adscendens* Lindl.; *A. subgriseus* Rydb.; *A. oblongifolius, A. richardsonii* of Fraser and Russell, ed 3, not Nutt. or Spreng.).—Ascending-stemmed Aster. Occasional on prairie and plain. Floral, Warman, Saskatoon, Hodgeville (UNS); Cypress Hills (CAN, DAO); Nokomis (UNS, DAO); Watson (DAS, as *A. oblongifolius*).

A. ciliolatus Lindl. (*A. lindleyanus* Torr. & Gray; *A. wilsonii* Rydb.).—Lindley's Aster. Common in woods; widely distributed.

A. conspicuus Lindl.—Showy Aster. Frequent in wooded areas northward and common in the Cypress Hills.

A. eatoni (A. Gray) Howell (*A. mearnsii* Rydb.; *A. oreganus* of Cronq., not Nutt.).—Eaton's Aster. Along springs in wet thickets and woods in the Cypress Hills (CAN, UNS, DAO). See: Cronquist in Leaflets of Western Botany 7:22, 1953.

A. falcatus Lindl. (*A. commutatus* (Torr. & Gray) A. Gray; *A. polycephalus* Rydb.).—Creeping White Prairie Aster. Frequent on dry prairie. Stems from slender creeping rhizomes; stems appressed-hairy; involucre 5-8 mm high.

A. falcatus var. *crassulus* (Rydb.) Cronq. (*A. crassulus* Rydb.; *A. adsurgens* Greene).—Common on prairie. Stems with spreading hairs.

A. hesperius A. Gray (*A. ciliomarginatus, A. osterhoutii, A. franklinianus, A. tweedyi* of Fraser and Russell, not Rydb.; *A. coerulescens* [*A. prealtus*] of western auth., not DC.; *A. paniculatus, A. longifolius, A. salicifolius* of Amer. auth., not Lam.).—Western Willow Aster. Common in wet meadows and shores.

A. junciformis Rydb. (*A. junceus* of auth., not Ait., *A. franklinianus* Rydb.).—Rush Aster. Frequent in swamps and bogs. *A. longulus* appears to be a hybrid between *A. junciformis* X puniceus.

A. laevis L. var. *geyeri* A. Gray (*A. geyeri* (A. Gray) Howell).—Common and widespread on prairie and around bluffs. Typical *A. laevis* occurs east of the Great Plains.

A. modestus Lindl. (*A. major* (Hook.) Porter).—Modest Aster. Along shores in wooded areas northward. Meadow Lake, Loon Lake, Ile a la Crosse (DAO).

A. novae-angliae L.—New England Aster. Saskatoon, W. P. Fraser, Aug. 1921. Not collected again. Perhaps from a cultivated plant.

A. pansus (Blake) Cronq. (*A. multiflorus* L. var. *pansus* Blake; *A. ericoides* [*A. stricticaulis*] of western reports, not L.).—Tufted White Prairie Aster. Common on prairie and extending northward into the semi-wooded areas to Meadow Lake. Stem clustered (cesiptose) from a thick caudex or very short rhizome rarely 1 cm long; heads 3-6 mm high. The nearly complete lack rhizomes distinguishes *A. pansus* from the very rhizomous *A. falcatus* with which it is sometimes associated. Our *A. pansus* has long been confused with the eastern *A. ericoides* which differs by producing long slender rhizomes.

A. pauciflorus Nutt.—Few-flowered Aster. Sandy, slightly alkaline meadows on prairie; rare. Gull Lake, Edam (UNS); Mortlach (DAO).

A. ptarmicoides (Nees) Torr. & Gray. (*Unamia alba* (Nutt.) Rydb.).—White Sneezewort Aster. Frequent on moist prairie, eroded hillsides and rocky shores.

A. ptarmicoides var. *lutescens* (Lindl.) A. Gray (*A. lutescens* (Lindl.) Torr. & Gray; *Unamia lutescens* (Lindl.) Rydb.).—Yellow Sneezewort Aster. Rare on prairie. Indian Head, Touchwood Hills (CAN).

A. puniceus L.—Purple-stemmed Aster. Common in swamps northward.

Bahia oppositifolia (Nutt.) DC. (*Picardeniopsis oppositifolia* (Nutt.) Rydb.).—Opposite-leaved Bahia. Alkaline soil on prairie; rare. Pambrum (DASC, DAO, CAN).

Bidens beckii Torr. (*Megalodonta beckii* (Torr.) Greene).—Water Marigold. In quiet water near Cumberland house on the Saskatchewan River (UNS).

B. cernua L. (*B. glaucescens* Greene).—Nodding Beggar-ticks. Frequent along margins of lakes and streams. McKague, Prince Albert, Pike Lake, Emma Lake, Swift Current, Cypress Hills.

B. vulgata Greene.—Tall Beggar-ticks. Occasional in and around sloughs in the prairie region. Maple Creek (UNS); Lumsden, Qu'Appelle Valley, Gainsborough (DAO).

B. vulgata forma *puberula* (Wieg.) Fern. (var. *puberula* (Wieg.) Greene; *B. puberula* (Wieg.) Rydb.).—Downy Beggar-ticks. Low moist prairie. Regina, Wordsworth (UNS); Nokomis (DAO).

Boltonia asteroides (L.) L'Her.—Aster-like Boltonia. Scarce on prairie in the southeastern part of the area. Weyburn, Torquay (UNS).

**Carduus nutans* L.—Nodding Thistle. Waste places and roadsides. Craik, Davidson, Renown (UNS); Wilkie, Craven, Dundurn (DAO). Reported from Mortlach by Hudson in Can. Field-Nat. 65:209, 1951.

**Centaurea repens* L. (*C. picris* Pall.).—Russian Knapweed. Occasional in fields, waste places and along roadsides. Gull Lake, Indian Head, Landis, Maxim, Tompkins.

**C. solstitialis* L.—Yellow Star Thistle. Waste place near Scott (UNS).

**Chrysanthemum lecanthemum* L. (*Leucanthemum vulgare* Lam.).—Ox-eye Daisy. Occasional along roadsides. Tisdale (DAO); Crooked River, Waskesiu Lake, Montreal Lake, Regina (UNS).

Chrysopsis villosa (Pursh) Nutt. (*C. hirsutissima* Greene; *C. bakeri, C. ballardii* Rydb.; *C. angustifolia* of Fraser and Russell, ed 3, not Rydb.).—Villose Golden Aster. Occasional on dry hills and plains. Chochin, Swift Current (DAS); Saskatoon (UNS, DAS); Bethune (DAS). *C. villosa* var. *angustifolia* (Rydb.) Cronq. is more southern, ranging from Missouri to Nebraska and Texas.

C. villosa var. *hispida* (Hook.) A. Gray (*C. hispida* (Hook.) DC.; *C. butleri* Rydb.).—Hispid Golden Aster. Frequent on prairie and plain.

Chrysothamnus nauseosus (Pall.) Britt. (*C. frigidus* Greene).—Rabbit Brush. Occasional on dry eroded hillsides and badlands in the southwestern part of the area. Cypress Hills, Cadillac, Val Marie.

C. nauseosus var. *graveclens* (Greene) Hall (*C. graveolens* Greene).—North bank of Souris River near Estevan (DAO).

**Cirsium arvense* (L.) Scop.—Creeping Thistle. Common in cultivated fields; difficult to eradicate. In North America, erroneously called "Canada Thistle." Naturalized from Europe—not from Canada. The white-flowered forma *albiflorum* (Rand & Redf.) R. Hoffm. occurs sparingly with the species.

**C. arvense* var. *integrifolium* Wimm. & Grab. (*C. setosum* (Willd.) Bieb).—Entire-leaved Creeping Thistle. Occasional in cultivated fields.

**C. arvense* var. *vestitum* Wimm. & Grab.—Hairy Entire-leaved Creeping Thistle. Sandy roadside. Grandora (DAO, DAS).

C. flodmanii (Rydb.) Arthur (*C. oblanceolatum* (Rydb.) K. Schum.).—Flodman's Thistle. Common on prairie. The white flowered form *albiflorum* Löve is known from Tyvan (DAO, DASC) and Swift Current (DAS). Reports of *C. plattense* from the area are erroneous. See: Rhodora 55(660):362-363, 1953.

C. foliosum (Hook.) DC. (*C. drummondii* Torr. & Gray).—Leafy Thistle. Occasional in wooded areas and valleys northward. McKague, Wallwort, Prince Albert National Park, Smeaton, Rosthern.

C. muticum Michx.—Swamp Thistle. Occasional in swamps and damp thickets

northward. McKague, Algrove, Kamsack, Sturgis, Waskesiu Lake. The milky-flowered forma *lactiflorum* Fern. has been collected at McKague (DAO).

C. undulatum (Nutt.) Spreng. (*C. engelmanii* Rydb.; *C. brevifolium* of Sask. report by Rydb., in Fl. Rocky Mts. & Adj. Pl. 1008, 1922, not Nutt.).—Wavy-leaved Thistle. Common on prairie and plain.

C. undulatum var. *megacephalum* (A. Gray) Fern. (*C. megacephalum* (A. Gray) Cockrell).—On dry plains in southwestern part of the area. Maple Creek, Cypress Hills (DAO).

**C. vulgare* (Savi) Airy-Shaw (*C. lanceolatum* Scop., not Hill).—Bull or Scotch Thistle. Roadsides and waste places. Cypress Hills, Dana, Tompkins.

Conyza canadensis (L.) Cronq. (*Erigeron canadensis* L.; *Leptilon canadense* (L.) Britt.).—Horse-weed. Common in waste places and neglected fields.

Coreopsis tinctoria Nutt. (*C. atkinsoniana* of Sask. report by Sheriff in Field Mus. Nat. Hist. Bot. Ser. 11:429, 1936, not Dougl.).—Golden Coreopsis. Frequent in moist depressions on prairie.

Echinacea angustifolia DC. (*Brauneria angustifolia* (DC.) Heller).—Purple Cone-flower. Occasional on dry river banks in SE Sask. Carnduff, Estevan (UNS).

**Echinops sphaerocephalus* L.—Globe Thistle. Escaped from cultivation into waste places. Regina, Saskatoon (UNS).

Erigeron acris L. var. *asteroides* (Andrs. ex Bess.) DC. (*E. droebachensis* Muell.; *E. asteroides* Andrs.; *E. angulosus* Gaudin var. *kamtschaticus* (DC.) Hara).—Tall White Fleabane. Occasional in coniferous woods. McKague, Montreal Lake (UNS, DAO); Lake Athabaska (Raup).

E. asper Nutt. (*E. oblanceolatus* of Fraser & Russell, not Rydb.).—Rough Fleabane. Common on prairie. Biennial with a taproot; stem erect with appressed pubescence; rays white.

E. asper var. pubescens (Hook.) Breitung, trans. nov. (*E. glabellus* var. *pubescens* Hook., Fl. Bor. Amer. 2:19, 1934; *E. anodontus, E. oligodontus* Lunnell).—Frequent on dry prairie. Stem with spreading pubescence; rays white.

E. asper var. **pubescens** forma **roseata** (Lunnell) Breitung, trans. nov. (*Tessenia oligodonta* var. *roseata* Lunnell, Amer. Midl. Nat. 5:59, 1917; *E. drummondii* Greene.).—Associated with var. *pubescens* but less common. Rays pink.

E. caespitosus Nutt. (*E. subcanescens* Rydb.; *E. pumilus, E. condensatus* of Sask., reports, not Nutt. or A. Nels.).—Tufted Fleabane. Frequent on dry prairie.

E. compositus Pursh (*E. trifidus* Hook.; *E. compositus* var *glabratus* Macoun; *E. compositus* var. *discoideus* forma *trifidus* (Hook.) Fern.).—Compound fleabane. Occasional on dry hills in the prairie region. Biggar, Southey, Elrose (UNS); Moose Mtn. Creek (CAN); Cypress Hills (CAN, DAO); Mortlach (DAO). *E. compositus sens. lat.* includes some poorly differentiated forms.

E. glabellus Nutt. (*E. speciosus* of Fraser & Russell, not DC.).—Smooth Fleabane. Common in semi-wooded areas. Perennial with a caespitose rootstock, stems decumbent at base; rays purple.

E. hyssopifolius Michx.—Hyssop-leaved Fleabane. Rocky slope at Amisk Lake (DAS).

E. lonchophyllus Hook. (*E. minor* (Hook.) Rydb).—Hirsute Fleabane. Frequent in damp meadows. *E. minor* is merely a depauperate form of *E. lonchophyllus*.

E. ochroleucus Nutt. var. *scribneri* (Canby) Cronq. (*E. macounii* Greene; *E. peucephallus* [*E. linearis*] of Sask. reports, not A. Gray).—Scribner's Fleabane. Cypress Hills; Macoun, June 28, 1894 (Mo. Bot. Gard.). See: Cronquist in Brittonia 6:189, 1947.

E. philadelphicus L. (*E. purpureus* Ait.).—Philadelphia Fleabane. Common in meadows; widely distributed.

E. pumilus Nutt.—Plains Fleabane. Collections from Sutherland (UNS, DAS) are tentatively assigned to this species but may prove to be *E. caespitosus*.

E. radicatus Hook.—Dwarf Fleabane. Crests of dry exposed hills. Moose Mtn. Creek, Old Wives Lake (CAN); Cypress Hills (CAN, DAO). Perhaps not distinct from *E. ochroleucus* as suggested by Cronquist, page 190, loc. cit.

**E. strigosus* Muhl. ex Willd. (*E. ramosus* (Walt.) BSP.).—Daisy Fleabane. Roadsides. Pre Ste Marie, Hudson Bay Junction, Saskatoon (UNS, DAO).

Eupatorium maculatum L. var. *bruneri* (A. Gray) Breitung, Can. Field-Nat. 61:98, 1947. (*E. bruneri* A. Gray).—Bruner's Trumpet-weed. Occasional along rivers and in the forested region northward. Madge Lake, Hudson Bay Junction, Nipawin, Green Lake, Beauval, and near mouth of the Beaver River south of Ile a la Crosse (UNS, DAO). Reported in Macoun's Cat. Can. Plants "North to the Clearwater River, lat. 57°".

E. rugosum Houtt. (*E. urticaefolium* Richard).—White Snakeroot. Weyburn prairie, eastern Saskatchewan, N. B. Sanson, 137, no date (NY). The locality of this species and of *Vernonia fasciculata* are questionable and must remain so until substantiated by additional specimens from our area. The specimens were probably collected in Manitoba where these species are definitely known to occur.

Gaillardia aristata Pursh.—Blanket Flower, Great-flowered Gaillardia. Common on prairie. Occasionally cultivated.

G. aristata forma *monochroma* Boivin.—Bank of Saskatchewan River at Petrofka Ferry near Waldheim. Disc-corollas and ligules wholly yellow. Associated with the typical phase.

Gnaphalium palustre Nutt.—Western Marsh Cudweed. Occasional in moist depressions on prairie. Floral, Rosthern, Saskatoon, Val Marie, Weyburn, Yeomans, Mortlach.

G. uliginosum L.—Marsh Cudwed. In damp soil near Loon Lake (DAO).

Grindelia squarrosa (Pursh) Dunal var. *quasiperennis* Lunell (*G. perennias* A. Nels.).—Curly-cup Gum-weed. Common in dried up potholes on prairie.

G. squarrosa var. *serrulata* (Rydb.) Styerm. (*G. serrulata* Rydb.).—Dry prairie Ogema (DAS).

Gutierrezia sarothrae (Pursh) Britt. & Rusby (*G. diversifolia* Greene).—Broomweed. Common on prairie and exposed hills.

Haplopappus acaulis (Nutt.) A. Gray (*Stenotus acaulis* Nutt.; *S. caespitosus* Nutt.; *H. acaulis* var. *glabratus* D.C. Eaton; *Stenotus armerioides* of Sask. reports, not Nutt.). —Stemless Stenotus. Occasional on dry windswept hills and plains. Whitehsore Lake, Cypress Hills (CAN); Eastend, Elbow, Estevan, Floral, Lebret. (UNS; DAO; DASC).

H. lanceolatus (Hook.) Torr. & Gray (*Pyrrocoma lanceolata* (Hook.) Greene).—Lanceolate Pyrrocoma. Occasional in saline meadows. Cypress Hills, Swift Current, Bracken, Saskatoon, Watson, Mortlach (UNS); Whiteshore Lake (CAN).

H. lanceolatus ssp. *vaseyi* (Parry) Hall (*H. lanceolatus* var. *vaseyi* Parry; *P.* vaseyi (Parry) Rydb.; *P. integrifolia* of reports from Sask. by Rydberg, Fl. Rocky Mtn. Adj. Pl. 863, 1922, and by Fraser and Russell, loc. cit. 58, not Greene).—Vasey's Pyrrocoma. Moist meadow. Patience Lake (UNS). A specimen collected by E. Bourgeau in 1858, is annotated "Saskatchewan" without locality (GH).

H. nuttallii Torr. (*Sideranthus grindelioides* (Nutt.) Britt.).—Toothed Iron Plant. Occasional on dry plains in the southwestern part of the area. Cypress Hills, Swift Current, Bracken, Moose Jaw, Mortlach.

H. spinulosus (Pursh) DC. (*Sideranthus spinulosus* (Pursh) Sweet).—Spinulose Iron Plant. Frequent on dry prairie and exposed hills.

Helenium autumnale L.—Sneeze-weed. Occasional along streams in woods northward. Meadow Lake, Beaver River, Ile a la Crosse (DAO). Var. *grandiflorum* A. Gray (*H. macranthum* Rydb.) occurs west of the Cascades.

H. autumnale var. *montanum* (Nutt.) Fern. (*H. montanum* Nutt.).—Mountain Sneeze-weed. Occasional around sloughs in the prairie region. Bracken, Pike Lake, Saskatoon, Swift Current, Unity (UNS); Mortlach (DAO).

Helianthus annuus L. (*H. lenticularis* Dougl.; *H. aridus* Rydb.).—Showy Sunflower. Common in rich clay soils in the prairie region; sometimes adventive in cultivated fields and along roadsides. Stems branching; heads 2-5 cm across.

**H. annuus* var. *macrocarpus* (DC.) Cockerell.—Giant Sunflower. Cultivated and occasionally escaped. Stem unbranched, 2-4 m high; heads 1-2 dm across.

H. giganteus L. (var. *subtuberosus* Bourgeau).—Tall Wild Sunflower. Frequent along lakes and streams northward.

H. laetiflorus Pers. var. *subrhomboideus* (Rydb.) Fern. (*H. subrhomboideus* Rydb.).—Rhombic-leaved Sunflower. Common on prairie.

H. maximilliani Schrad.—Maximillian's Sunflower. Occasional on prairie. Tisdale, Quill Lake, St. Front, Dundurn, Humboldt (UNS); Mortlach (DAO).

H. nuttallii Torr. & Gray (*H. fascicularis* Greene).—Clustered Sunflower. Occasional in moist river valleys in the southcentral and southwestern part of the area. Yorkton, Hodgeville, Indian, Head, Swift Current (UNS); Cypress Hills (DAO).

H. petiolaris Nutt.—Prairie Sunflower. Frequent on dry sandy prairie.

Heliopsis helianthoides (L.) Sweet var. *scabra* (Dunal) Fern. (*H. scabra* Dunal; *Helianthus divaricatus* of Sask. reports, not L.).—Sunflower Heliopsis. Semi-open woods in central eastern part of the area. McKague, Tisdale (UNS, DAO, CAN, as *Helianthus divaricatus*).

Hymenopappus filifolius Hook.—Tufted Hymenopappus. Scarce on eroded hills along the southern border. Rockglen, Big Muddy Valley, Ormiston (UNS, DASC).

Hymenoxys acaulis (Pursh) Parker (*Actinea acaulis* (Pursh) Spreng; *Tetraneuris acaulis* (Pursh) Greene; *T. septentrionalis* Rydb.; *T. simplex* A. Nels.).—Stemless Hymenoxys. Eroded hillsides. Cypress Hills (CAN).

H. richardsonii (Hook.) Cockerell (*H. macounii* (Cockerell) Rydb.).—Richardson's Hymenoxys. Frequent on dry plains, becoming abundant with overgrazing.

Liatris aspera Michx. (*Lacinaria aspera* (Michx.) Greene).—Harsh Blazing Star. Moist prairie in the southeastern part of the area. Gainsborough, Antler (UNS, DAO).

L. ligulistylis (A. Nels.) K. Schum. (*Lacinaria ligulistylis* A. Nels.).—Meadow Blazing Star. Common on prairie and in meadows.

L. punctata Hook. (*Lacinaria punctata* (Hook.) Kuntze.).—Dotted-leaved Blazing Star. Common on dry hills and plains.

Madia glomerata Hook.—Tarweed. Occasional around dried up ponds, open hillsides and roadsides on prairie in SW Saskatchewan. Cypress Hills, Val Marie, Regina, Tompkins.

**Matricaria chamomilla* L. (*Chamomilla chamomilla* (L.) Russell, Ledingham & Coupland in Fraser and Russell).—Fragrant Camomile. Occasional in farm yards and waste places. Rosthern (UNS); Rhein, Watrous (DAO); Crooked River (DAO, Breitung 629, as *M. inodora* in Can. Field-Nat. 61:99, 1947); Cherryfield, Macoun & Herriot 72860 (CAN, as *Anthemis cotula*).

**M. maritima* L. var. *agrestis* (Knaf) Wilmott (*M. inodora* L.; *Chamomilla inodora* (L.) Gilib.).—Scentless Camomile. Frequent along roadsides and in waste places. Pelly, Regina, Balgonie (UNS); Regina, Vonda, Turtleford, Tisdale, Sylvania, Edenwold (DAO); Quill Lake (UNS, DAO); Emma Lake (DAS).

**M. matricarioides* (Less.) Porter (*M. suaveolens* (Pursh) Buch., not L.; *Chamomilla suaveolens* (Pursh) Rydb.).—Pineapple Weed. Common in dooryards, vacant lots and waysides. Adventive from west of the Rocky Mountains.

Petasites frigidus (L.) Fries var. *nivalis* (Greene) Cronq. (*P. vitifolius*, *P. trigonophyllus* Greene).—Vine-leaved Colt's Foot. Occasional in wet woods. McKague, Kenosee Lake, Sutherland (UNS); Tisdale, Cypress Hills (DAO); Lake Athabaska (Raup). See: Cronquist in Leaflets of Western Botany 7:30, 1953.

P. frigidus var. *palmatus* (Ait.) Cronq. (*P. palmatus* (Ait.) A. Gray.—Palmate-leaved Colt's Foot. Common in woods.

P. sagittatus (Pursh) A. Gray.—Arrow-leaved Colt's Foot. Common in marshes and swamps through the wooded sections.

Ratibida columnifera (Nutt.) Wooton & Standl. (*R. columnaris* (Sims) D. Don; *Lepachys columnifera* (Nutt.) Rydb.; *L. columnaris* (Sims) Torr. & Gray).—Prairie Cone-flower. Frequent on dry prairie and plains. Rays yellow.

R. columnifera forma *pulcherrima* (DC.) Fern. (*R. columnifera* var. *pulcherrima* (DC.) Wooton & Standl.).—Brown-rayed Cone-flower. Rays partially or wholly brown-purple. Associated with the typical species; scarce. Bengough, Saskatoon (UNS); Mortlach (DAO).

Rudbeckia hirta L. (*R. serotina* Nutt.).—Black-eyed Susan. Common in parkland.

Senecio canus Hook. (*S. purshianus* Nutt.).—Silvery Groundsel. Frequent on dry prairie and hills.

S. cymbalarioides Nutt. var. *borealis* (Torr. & Gray) Greenm.—Northern Groundsel. Occasional on dry uplands around Lake Athabaska (Raup).

S. erymophilus Richards.—Cut-leaved Ragwort. Frequent in wooded areas northward.

S. integerrimus Nutt. (*S. columbianus* Greene; *S. scribneri* Rydb.).—Entire-leaved Ragwort. Frequent and widespread in moist meadows of the prairie region.

S. integerrimus var. *exaltatus* (Nutt.) Cronq. (*S. exaltatus* Nutt.; *S. hookeri* Torr. & Gray).—Tall Ragwort. Wet openings in wooded parts of the Cypress Hills (UNS, CAN, DAO, DASC).

S. congestus (R. Br.) DC. var. *palustris* (L.) Fern. (*S. palustris* (L.) Hook., not Velleso).—Marsh Ragwort. Common on muddy shores of lakes and sloughs. Typical *S. congestus* is a dwarf arctic plant, whereas var. *palustris* is the high-grown subarctic phase present in our area.

S. pauperculus Michx. (*S. willingii* Greenm.; *S. plattensis, S. densus* of Fraser and Russell, not Nutt., or Greene).—Depauperate Groundsel. Occasional in swampy meadows to dry, semi-open prairie. Snowden, McKague, Dundurn, Floral, Saskatoon, Meadow Lake, Pilger, Prince Albert National Park, Warman, Saskatchewan Landing, Bulyea, Cypress Hills (UNS, DAS, DAO). Stems 2-4 dm high.

S. pauperculus var. *thomsoniensis* (Greenm.) Boivin (*S. balsamitae* Muhl. var. *thomsoniensis* Greenm.; *S. flavovirens* Rydb.; *S. flavulus* Greene; *S. multnomensis* Greenm.; *S. tweedyi* Rydb.).—Damp thickets and meadows in the Cypress Hills (DAO, DAS, DASC, UNS). This is the Cordilleran variety of the species, distinguished chiefly by being taller, 4-7 dm high, with basal leaves often elliptic to ovate or broadly oval. It has been confused with *S. pseudaureus* and *S. indecorus* which are different species.

S. plattensis Nutt. (*S. densus* Greene; *S. manitobensis* Greenm.).—Prairie Groundsel. Known in our area thus far only from prairie near Riversdale north of Spy Hill in SE Saskatchewan, Macoun 69757 (CAN).

S. pseudaureus Rydb.—Thin-leaved Groundsel. Occasional in sedge meadows and thickets in wooded areas northward. McKague, Orley, Waskesiu Lake (UNS, DAO); Emma Lake, Amisk Lake (DAS).

S. vulgaris L.—Common groundsel. Frequent weed in gardens and waste places.

**Silybum marianum* (L.) Gaertn.—Milk Thistle. A garden weed at Eastend (DASC). See: The Blue Jay 9(4):23, 1951.

Solidago canadensis L. var. *gilvocanescens* Rydb. (*S. gilvocanescens* (Rydb.) Smyth; *S. pruinosa* Greene; *S. dumetorum* Lunell; *S. lunellii* Rydb.).—Canescent Goldenrod. Common on prairie and plain.

S. canadensis var. *salebrosa* (Piper) M. E. Jones (*S. lepida* DC.; *S. elongata* Nutt.; *X leiophallax* Friesner).—Graceful Goldenrod. Common in the forested area northward and in the Cypress Hills.

S. gigantea Ait. var. *serotina* (Kuntze) Cronq. (*S. gigantea* var. *leiophylla* Fern.).—Late Goldenrod. Common in aspen woods, valleys and banks.

S. graminifolia (L.) Salisb. var. *major* (Michx.) Fern. (*Euthamia camporum* [*S. graminifolia* var. media] of western reports, not Greene).—Flat-topped Goldenrod. Frequent along shores of lakes and streams, especially northward.

S. hispida Muhl. var. *lanata* (Hook.) Fern. (*S. lanata* Hook.; *S. bicolor* of Sask. reports, not L.).—Shaggy Goldenrod. Common on dry, semi-open woods northwestward to Ile a la Crosse on the Churchill River.

S. missouriensis Nutt. (*S. glaberrima* Martens; *S. juncea* of western reports, not Ait.).—Low Goldenrod. Common on dry prairie and plain.

S. mollis Bartl.—Velvety Goldenrod. Common on dry plains.

S. multiradiata Ait. var. *scopulorum* A. Gray. (*S. scopulorum* (A. Gray) A. Nels.).—Northern Goldenrod. Rare in moist woods. Waskesiu Lake (UNS); Ile a la Crosse (DAO). Perhaps only a high-grown phase of the typical arctic and alpine form.

S. nemoralis Ait. var. *decemflora* (DC.) Fern. (*S. pulcherrima* A. Nels.; *S. longipetiolata* Mack. & Bush).—Showy Goldenrod. Frequent in dry sandy, open woods, meadows and prairie.

S. rigida L. var. *humilis* Porter (*S. rigida* var. *canescens* (Rydb.) Breitung; *Oligoneuron canescens* Rydb.).—Corymbose Goldenrod. Frequent on dry prairie.

S. spathulata DC. var. *neomexicana* (A. Gray) Cronq. (*S. glutinosa* Nutt.; *S. decumbens* Greene var. *oreophila* (Rydb.) Fern.; *S. oreophila* Rydb.).—Mountain Goldenrod. Frequent on sandy soil in wooded and semi-wooded areas.

Tanacetum bipinnatum (L.) Schulz-Bip. ssp. **huronense** (Nutt.) Breitung, stat. nov. (*T. huronense* Nutt., Gen. 2:141, 1818; *Chrysanthemum huronense* (Nutt.)

Hultén).—Lake Huron Tansy. Common on shore of Lake Athabaska, where it is among the more important dune-fixing plants (Raup). Variable in stature and amount of indument, forms of which have been segregated as var. *bifarium* Fern. and var. *floccosum* Raup.

**T. vulgare* L.—Tansy. Occasional as a garden escape along roadsides and in waste places.

**T. vulgare* var. *crispum* (L.) DC. (forma *crispum* (L.) Hayek).—Frequent along roadsides. Leaflets deeply cut and crisped.

Townsendia sericea Hook. (*T. excapa* (Richards.) Porter).—Low Townsendia. Occasional on dry exposed hills, river banks and badlands in the prairie region. Cypress Hills, Ardath, Diggar, Donavon, Fort Qu'Appelle, Lac Pelletier, Lumsden, Maple Creek, Southey, Mortlach.

Vernonia fasiculata Michx.—Western Iron-weed. Weyburn prairie, eastern Saskatchewan, N. B. Sanson, 136, no date (NY). Included in our flora with some hesitation. Additional specimens from the are are desired.

LIGULIFLORAE—Chicory Subfamily

Agoseris glauca (Pursh) Raf.—(*A. parviflora* of Sask. reports, not Nutt.).—Smooth Agoseris. Common in moist meadows and low prairie.

A. glauca var. *agrestis* (Osterh.) Q. Jones (*A. agrestis* Osterh.; *A. turbinata* Rydb.; *A. scorzoneraefolia* of Sask. reports, not Greene).—Common on dry prairie and hills.

**Cichorium intybus* L.—Chicory.—Waste place near Kinestino (UNS).

Crepis intermedia A. Gray (*C. acuminata* Nutt. var. *intermedia* (A. Gray) Jepson).—Small-flowered Hawksbeard. Farwell Creek in the Cypress Hills, Macoun 5080 (CAN).

C. occidentalis Nutt. ssp. *costata* (A. Gray) Babcock & Stebbins (var. *costata* A. Gray).—Western Hawksbeard. Farwell Creek in the Cypress Hills, Macoun 11709 (CAN). Macoun has collected three related species of Crepis in the Cypress Hills, i.e., *C. intermedia* and *C. occidentalis* on the Saskatchewan side and *C. exilis* on the Alberta side of the hills. These taxonomic units are arbitrary, representing polyploid-apomictic complexes connected by a series of intergrades. For a study of "The American Species of Crepis" see: Babcock and Stebbins in Carn. Inst. Wash. Publ. 504:1-199, 1938.

C. runcinata (James) Torr. & Gray (*C. glaucella, C. perplexans* (Rydb.).—Scapose Hawk's-beard. Frequent in moist saline meadows.

C. runcinata ssp. *glauca* (Nutt.) Babcock & Stebbins (*C. glauca* (Nutt.) Torr & Gray).—Smooth Hawk's-beard. Occasional on moist prairie. Brock, Floral, Fulda, Saskatoon, Pike Lake, Waskesiu Lake, Wadena (UNS); Little Manitou Lake (CAN).

C. runcinata ssp. *hispidulosa* (Howell) Babcock & Stebbins (*C. platyphylla* Greene; *C. runcinata* var. *hispidulosa* Howell).—Broad-leaved Hawk's-beard. Occasional in fescue grassland on the Cypress Hills plateau (UNS, DAO, DAS, DASC).

**C. tectorum* L. (*Picris echioides* of Fraser and Russell, not L.).—Narrow-leaved Hawksbeard. Waste places and railway embankments. Prince Albert, Biggar, Yorkton, Nipawin, Saskatoon (UNS, DAO); Shellbrook, Leask, St. Laurent (DAS).

Hieracium albiflorum Hook.—White-flowered Hawkweed. Lodgepole pine woods in the Cypress Hills (UNS, DAO).

H. umbellatum L. (*H. scabriusculum* Schwein).—Narrow-leaved Hawkweed. Abundant in woods and open hillsides. Stem scabrous to puberulent.

H. umbellatum var. **canadense** (Michx.) Breitung, stat. nov.(*H. canadense* Michx., Fl. Bor. Amer. 2:86, 1803; *H. columbianum* Rydb.).—Canada Hawkweed. Pine woods in the Cypress Hills (DAO, DASC, UNS); Meadow Lake (DAO). Stem with spreading hairs.

**Hypochaeris radicata* L.—Cat's Ear. Weed in garden at Scott (UNS).

Lactuca biennis (Moench) Fern. (*L. spicata* of Hitchc., not *Sonchus spicatus* Lam.; *L. multifida* Rydb.).—Tall Blue Lettuce. Occasional in swampy woods. Big River, Emma Lake, Hudson Bay Junction, Madge Lake, Speddington, McKague, Waskesiu Lake (UNS); Cypress Hills (DAO).

L. ludoviciana (Nutt.) Riddell (*L. campestris* Greene).—Western Lettuce. Moist river banks. Regina Gainsborough (UNS).

**L. serriola* L. (*L. scariola L.*).—Lobed Prickly Lettuce. Common in waste places and along roadsides.

L. tatarica (L.) C. A. Mey ssp. *pulchella* (Pursh) Stebbins (*Sonchus pulchellus* Pursh; *L. pulchella* (Pursh) DC.).—Blue Lettuce. Common on moist prairie, dry banks and occasionally as a weed in cultivated fields.

Lygodesmia juncea (Pursh) D. Don.—Rush-like Skeleton Weed. Common on sandy prairie.

L. rostrata A. Gray.—Beaked Annual Skeleton Weed. Scarce on sandhills and eroded banks. Beverly, Mortlach (DAO); Cypress Hills (CAN).

Microseris cuspidatum (Pursh) Schulz-Bip. (*Troximon cuspidatum* Pursh; *Agoseris cuspidata* (Pursh) Raf.; *Nothocalais cuspidatum* (Pursh) Greene).—Cuspidate Small Lettuce. Scarce on prairie. Lebret, Lumsden (UNS).

Prenanthes alba L. (*Nabalus albus* (L.) Hook.).—White Lettuce. Occasional in rich woods and thickets. Madge Lake, Kenosee Lake, Battleford.

P. racemosa Michx. (*N. racemosus* (Michx.) DC.).—Glaucous White Lettuce. Frequent in open woods.

**Sonchus arvensis* L.—Perennial Sowthistle. A common and persistent weed in cultivated fields; difficult to eradicate.

**S. arvensis* var. *glabrescens* Guenth., Grab. & Wimm. (*S. uliginosa* Bieb.).—Associated with the typical species and equally common.

**S. asper* (L.) Hill.—Spiny Annual Sowthistle. Occasional in gardens and waste places. Tisdale, Meota, Regina, Saskatoon, Yorkton (UNS, DAO).

**S. oleraceous* L.—Common Annual Sowthistle. Frequent in gardens.

Taraxacum ceratophorum (Ledeb.) DC. (*T. lacerum, T. dumetorum* Greene; *T. lapponicum Kilm.; Leontodon dumetorum* (Greene) Rydb.).—Horned Dandelion. Open woods, thickets and clearings. Lake Athabaska (Raup).

**T. laevigatum* (Willd.) DC. (*T. erythrospermum* Andrz.).—Red-seeded Dandelion. Occasional on dry soil. Foam Lake, Saskatoon, Swift Current.

**T. officinale* Weber (*L. taraxacum* L.).—Common Dandelion. Abundant in cultivated fields, lawns, waste places and established in the native sod.

**Tragopogon dubius* Scop. (*T. major* Jacq.).—Goat's Beard. Common in waste places, along railways and highways and established in native prairie.

Excluded Species

Many of the species reported from Saskatchewan in current manuals are based on the Bourgeau collections ambiguously annotated "Saskatchewan Plains," or by Richardson as "Cumberland House to Bear Lake," thus causing much confusion. Because no definite localities were recorded, it was considered advisable to delete from the Saskatchewan flora those species based on early indefinite records not supported by more recent collections. In addition, the distribution given for certain species is based on erroneously identified specimens or sometimes on closely related species not distinguished by the early botanists. The erroneous distribution originally given these species, have in many instances been perpetuated by subsequent authors. The copious collections made in recent years, indicate that many species have a more limited or more widespread distribution, as the case may be, than was formerly known.

Following is a list of species reported from Saskatchewan of which no authentic specimen could be found to confirm the report. The numbers in square brackets indicate the references where the doubtful "Sask." reports are recorded:

[1] CORRELL, D. S. 1950—Native Orchids of North America. Chronica Botanica, Waltham, Mass.

[2] FERNALD, M. L. 1950—Gray's Manual of Botany, ed. 8. American Book Co., New York.

[3] GLEASON, H. A. 1952—New Britton & Brown Illustrated Flora. New York.

[4] MACOUN, JOHN, 1883-1890—Catalogue of Canadian Plants. Montreal.
[5] RYDBERG, P. A. 1922—Flora of the Rocky Mountains and Adjacent Plains. New York.
[6]RYDBERG, P. A. 1932—Flora of the Prairies and Plains of Central North America. New York.

Osmunda regalis L. var. *spectabilis* (Willd.) A. Gray [2]
Asplenium viride Huds. [6]
Onoclea sensibilis L. [6]
Thuja occidentalis L. [2]
Sagittaria graminea Michx. [6]
Arctagorstis poaeoides Nash [6]
Hystrix patula Moench [6]
Leersia oryzoides (L.) Schw. [6]
Panicum leibergii (Vasey) Scribn. [2]
Sorghastrum nutans (L.) Nash [5]
Carex albolutescens Schw. [3]
C. bicknellii Britt. [2]
C. cumulata (Bailey) Mack [2,3]
C. granularis var. *haleana* Olney [2,3]
C. plantaginea Lam. [3]
C. subspathacea Wormsk. [4]
Eleocharis engelmanni Steud. [2]
E. tenuis (Willd.) Schult. [6].
E. wolfii A. Gray [2]
Scirpus atrovirens Willd. [2]
Alpectrum spicatum (Walt.) BSP. [2,6]
Cypripedium reginae Walt. [1]
Populus acuminata Rydb. [5,6]
P. angustifolia James [5,6]
Salix hookeriana Barratt [5]
Betula sandbergii Britt. [2,5]
Corylus americana Walt. [4]
Polygonum (Tracaulon) sagittatum L. [6]
Tripterocalyx micranthus (Torr.) Hook. [5,6]
Stellaria (Alsine) alpestris Fries [5,6]
Nuphar microphyllum (Pers.) Fern. [6]
Arabis rupestris Nutt. [5]
Physaria didymocarpa (Hook.) A. Gray [5,6]
Spiraea latifolia (Ait.) Borkh. [5,6]
Amorpha canescens Pursh [2]
A. fruticosa L. var. *angustifolia* Pursh [2]
A. nana Nutt. [2,6]
Desmodium (Meibomia) acuminata (Michx.) DC. [3,6]
D. canadense (L.) DC. [2]
Petalostemon villosum Nutt. [2,6]
Oxalis acetosella L. [6]
Euphorbia helioscopia L. [2]
Impatiens pallida Nutt. [2,6]
Oenothera (Sphaerostigma) andina Nutt. [5]
Gaylossacia baccata (Wang.) Koch [2,6]
Epigaea repens L. [2,3,6]
Vaccinium angustifolium Ait. var. *laevifolim* House (*V. pensylvanicum*) [2,6]
V. (Oxycoccus) macrocarpon Ait. [6]
Lysimachia terrestris (L.) BSP. [6]
Primula stricta Hornem. [6]
Gentiana (Dasystephana) puberula Michx. [5,6]
Polemonium occidentale Greene [5,6]
Physalis heterophylla Nees [2,6]
Gerardia (Agalinus) aspera Dougl. [5,6]
G. paupercula (A. Gray) Britt. [5,6]
Pedicularis lanceolata Michx. [5,6]
Sambucus canadensis L. [5,6]
Lobelia cardinalis L. [5,6]
L. inflata L. [2,6]
Artemisia michauxiana Bess. [5]
Aster johannensis Fern. [2]
A. (Doellingeria) umbellata Mill. [6]
A. umbellata var. *pubens* A. Gray [5,6]
Balsamorrhiza sagittata (Pursh) Nutt. [5,6]
Erigeron salsuginosus (Richards.) A. Gray [3,5]
Haplopappus (Pyrrocoma) uniflorus Torr. & Gray [5]
Helianthus grosseserratus Martens [3,5,6]
H. tuberosus L. [2,5,6]
Rudbeckia ampla A. Nels. [5,6]
Sausurea remotiflora (Hook.) Rydb. [5]
Senecio triangularis Hook. [5]
Solidago pallida (Porter) Rydb. [6]
S. speciosa Nutt. var. *angustata* Torr. & Gray [2]
Crepis (Youngia) elegans Hook. [5].

A large proportion of the entities in the above list of excluded species are either eastern, ranging into adjacent Manitoba or western, found in the Rocky Mountains and foothills of Alberta, but they are not known to occur within the present boundaries of Saskatchewan. These early records were made before the three Prairie Provinces were organized, when the whole Canadian plains region belonged to the territory of Saskatchewan. However, certain species, such as *Aster umbellatus* var. *pubens* is distinctly worthy of further investigation, occurring in both adjacent Manitoba to the east ("List of the Flowering Plants . . . of Manitoba" by C. W. Lowe, Nat. Hist. Soc. Man., 1943") and

in Alberta to the west ("Plants of the Edmonton District . . . Alberta" by G. H. Turner, Can. Field-Nat. 63:1-28, 1949).

A cause for erroneous plant distribution may occur in the process of labelling at the herbarium. For example, in the National Herbarium of Canada there are two sheets of *Panicum leibergii* collected by Macoun at McGregor (Manitoba); one sheet bears a label with the correct heading "Plants of Manitoba," whereas a second sheet bears the incorrect heading "Plants of Saskatchewan." The latter specimen was filed in a folder for Saskatchewan plants which likely is the basis of *P. leibergii* reported from "Sask." in the manuals.

A specimen of *Carex bicknellii* in the Gray Herbarium labelled "Saskatchewan Plains" collected by John Macoun, No. 93, Aug. 1, 1872, is presumably the basis of "Sask." included in the distribution given by Fernald in Gray's Manual, ed. 8, page 326, 1950. According to Macoun's autobiography, page 55, 1922, he was either at or just west of Fort Garry (Winnipeg) on Aug. 1, as the party arrived there from Oak Point, 30 miles to the east on July 31. Manitoba was not organized until later and the country from Fort Garry west was called "Saskatchewan Plains" on account of the absence of trees.

D. S. Correll in "Native Orchids of North America, page 41, 1950" reports *Cypripedium reginae* from "Sask." This record is based on a sheet in the Orchid Herbarium of Oakes Ames, Harvard University, labelled "*Cyprepidium spectabile,* Regina, Assiniboia, T. N. Willing, s.n.", Herb. Ames 301. *C. reginae* (*C. spectabile*) is an eastern forest species ranging west to Riding Mountain National Park, Manitoba (acc. to C. W. Lowe). Regina is located on the treeless plains of southern Saskatchewan (formerly Assiniboia). It is possible that while Willing was weed inspector and residing in Regina from 1899 to 1910, he could have visited or probably attended a weed conference in eastern Canada and collected some plants there, including *C. reginae,* which presumably were distributed later from Regina. There is no evidence that Willing collected plants prior to his coming west. The type of *Senecio willingii* was collected by him at Olds, Alberta, and described by Greenman in the Ottawa Naturalist 25:117-118, 1911.

The report of *Populus angustifolia* from Saskatchewan by Morton and Lewis (Native Trees of Canada, 1917) and subsequent authors is likely based on a sheet in the National Herbarium of Canada. This sheet bears two specimens collected by Macoun; one is *Populus balsamifera* collected in Alberta, and the other is *P. angustifolia* supposedly collected along the Frenchman River in the Cypress Hills, Saskatchewan. The locality of Macoun's record is questionable. It is possible the data was wrongly transposed on the sheet, so that the specimen of *P. balsamifera* came from the Cypress Hills where it is common and that *P. angustifolia* came from south-central Alberta. No authentic collections of *P. angustifolia* have been made in our area since Macoun's record of over half a century ago. It seems improbable that such a distinctive tree species with narrow, willow-like leaves on short petioles, should escape detection by subsequent botanists if it were present in our area. However, if it does occur, we hope it will be substantiated in the future. A specimen from Fish Creek near Hague north of Saskatoon (UNS) reported

by Fraser and Russell, *loc. cit.* 22, as *P. angustifolia* has proven to be *P. balsamifera.*

Salix hookeriana is a Pacific coast species and the "Sask." record is probably based on an erroneously identified specimen of the similar *S. scouleriana* which occurs in our area.

A sheet of *Spiraea alba* in the National Herbarium of Canada, collected in Saskatchewan by John Richardson, contains, in addition, twigs of *Spiraea latifolia.* The latter species is not known to occur in the region traversed by Richardson. Presumably, specimens of the similar *S. latifolia* were added at the Kew Herbarium, prior to furnishing the National Herbarium with duplicates of Richardson's collections. The *Spiraea* specimens on this sheet were annotated by P. A. Rydberg which probably accounts for including "Sask." in the range of *S. latifolia* given by him in Fl. Pr. Pl. Cent. N. Amer. 406, 1932. *Spiraea latifolia* is eastern and no authentic specimen was seen from west of the Great Lakes and it is not reported from Manitoba by Lowe, 1943, loc. cit.

Amorpha fruticosa var. *angustifolia,* reported from "Sask." (Gray's Man. ed. 8), is possibly based on the range given by Palmer, Journ. Am. Arb. 12:189, 1931. On page 191, loc. cit., Palmer cites a specimen from Manitoba ("Red River, E. Bourgeau") in the Gray Herbarium, but nowhere does he cite one from Saskatchewan. The Bourgeau specimen is probably annotated "Red River, Saskatchewan." Dr. N. C. Fassett informed me (personal correspondence) that "I saw no material [of *A. fruticosa* var. *angustifolia*] from Saskatchewan in any of the herbaria that I examined." It is very likely that *Amorpha canescens, A. nana* and many other species, reported from "Sask." are based also on the Bourgeau collections, which actually range up the Red River in southcentral and southeastern Manitoba.

The report of *Oenothera* [*Sphaerostigma*] *andina* from "Sask." by Rydberg, Fl. Rocky Mts. Adj. Pl. 601, 1922, is very likely based on two specimens from Canada: Assiniboia, Pend (ant) d'Orielle Post, Macoun in 1895 (GH); Medicine Hat, Macoun 7531 (GH). These specimens are cited by Munz under typical *O. andina* in Bot. Gaz. 85:250, 1928. Medicine Hat is located at 50°2'N, 110°W and Pendant d'Orielle is at 49°N, 110°58'W, in what is now SE Alberta.

A specimen of *Vaccinium canadense,* collected by Macoun in British Columbia (CAN), originally identified as *Vaccinium pensylvanicum* is likely the basis of the distribution "Newfoundland to the Rocky Mountains" given by Macoun in Cat. Can. Plants. *Vaccinium pensylvanicum* (now *V. angustifolium*) is eastern and according to specimens examined it ranges as far west as eastern Manitoba. It is reported from "Sask." in Gray's Man. ed 8, but no specimen could be located to support this report.

Gentiana ventricosa appears to be known only from the type locality "Grand Rapids of the Saskatchewan between Cumberland House and Hudson Bay," collected by Drummond. Grand Rapids is at the mouth of the Saskatchewan River on Lake Winnipeg, Manitoba. From 1882 to 1905 the district of Saskatchewan between Assiniboia and Athabasca extended eastward into the Lake Winnipeg region.

The present writer is unable to ascertain just what plant Macoun had

before him when he wrote under *Gilia aggregata* "On arid soil north of the Cypress Hills and at Red Deer Lake west of the Elbow of the South Saskatchewan River" in his Catalogue of Canadian Plants.

Rydberg in his floras gives the range of *Gilia congesta* as ranging into "Sask." No specimen of this species from Saskatchewan could be located in any herbaria including the New York Botanical Garden to support this report. It seems Rydberg's statements of range were sometimes based on his intuition of what the range would prove to be when known.

Fernald's inclusion of Saskatchewan in the range of *Aster johannensis* in Gray's Man., ed. 8, is undoubtedly based on specimens of the similar western *Aster hesperius,* which becomes difficult to distinguish from *A. johannensis* farther east in Canada.

The type of *Haplopappus uniflorus* was collected on "Plains of the Saskatchewan and prairies of the Rocky Mountains" by Drummond, which probably refers to the broad, plain-like valley bottom of the Saskatchewan River within the Rocky Mountains, where the species occurs, and not to the province of Saskatchewan. In addition, other collections made by Drummond are labelled "R. Mts., Saskatchewan." This and similar inadequate data on early collections likely is the basis for the erroneous inclusion of "Sask." in the distribution of certain Rocky Mountain species by Rydberg in Fl. Rocky Mts. Adj. Pl., 1922. Examples of such species appear to be *Artemisia michauxiana, Crepis elegans, Erigeron salsuginosus* and *Senecio triangularis,* as there does not seem to be any favorable habitat in our area to support these Cordilleran plants. *Physaria didymocarpa* and *Balsamorrhiza sagittata* occur in the Mountains and foothills of western Alberta and the inclusion of "Sask." in the distribution given in current manuals is probably based on early records before Alberta was organized.

Solidago bicolor is reported from Saskatchewan by E. W. Hart in "Keys to Goldenrods in Canada and Newfoundland," Dom. Dept. Agr. Publ. 565:26, 1938. This report is presumably based on a specimen of *S. hispida,* erroneously identified as *S. bicolor,* collected by Macoun on the Red Deer River, N.W.T., in 1881 (CAN). Macoun, in his autobiography, pages 186-196, describes going up the Red Deer River and down the Swan River and the Assiniboine to Fort Ellice in 1881. *Solidago bicolor* is eastern and no authentic specimen of this species was seen from west of the Great Lakes region.

Solidago juncea is eastern, ranging west into southeastern Manitoba and reports of it from "Sask." are probably based on a Bourgeau specimen annotated "Saskatchewan Plains" or on luxuriant specimens of *S. missouriensis,* with which it is sometimes confused.

The report of *Solidago speciosa* var. *angustata* from "Sask." in Gray's Man. ed 8, is likely based on a specimen collected at Eye Hill Creek, Sask., by Macoun and Herriot, No. 77098, Aug. 8, 1906 (CAN), which appears to be *S. spathulata* var. *neomexicana* (*S. oreophila*), a western plant ranging eastward to northern Michigan.

A Guide to the Flowering Plants and Ferns of the Western National Parks

Part 2.—Angiosperms
Monocotyledons (Hydrocharitaceae to Gramineae)

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Part 1 of A Guide to the Flowering Plants and Ferns of the Western National Parks[1] deals with the ferns and fern-like plants and the gymnosperms. The second part, in which treatment of the angiosperms is begun, includes several small families of water and marsh plants and the relatively large grass family, the latter making up the bulk of this section.

While records of distribution of species in many of the areas are still incomplete, the occurrence lists have been brought as up to date as possible through the cooperation of the naturalist division in each of the western parks and others interested in the floras of certain areas. Acknowledgment should be made to the park naturalists and their assistants, who so carefully made last-minute checks of their respective herbaria and check lists, and without whose assistance the records of occurrences would have been less complete and accurate. A number of species were added for Yellowstone National Park by Herma A. Baggley and for Glacier National Park by Dr. Leroy H. Harvey, Montana State University. J. R. Swallen, Curator of Grasses in the U. S. National Herbarium, kindly checked identifications of grasses collected in the western national parks, chiefly by H. and V. Bailey during the years 1948 to 1950. The aid of these investigators is very much appreciated.

Spermatophyta Seed-bearing Plants

ANGIOSPERMAE (Angiosperms)

MONOCOTYLEDONAE (Monocotyledons)

Ours herbaceous plants; leaves mostly linear to oblong or lance-shaped, or if expanded into broad blades, the main veins spreading outwards from base and tending to meet again at the tip; flower parts mostly in 3's, sometimes reduced or in 4's, never in 5's.

KEY TO THE FAMILIES

Aquatic plants with stems always submerged, sometimes with some of the leaves floating, or sometimes (in *Sparganium*) the stems erect and standing partly above the water.

Flowers with showy white perianth segments, borne singly in the leaf axils, the staminate flowers soon separating from the stem and floating, the pistillate on long

[1] Amer. Midl. Nat. 53:1-32. 1955.

leafless stems which lift them above the surface of the water until after pollination .... (Frog's-bit Family HYDROCHARITACEAE, p. 74.

Flowers with perianth none, or green and inconspicuous; leaves and flowers various.

Flowers borne singly or few in the axils of the leaves, or in rather loose spike-like clusters of several to many, the flowers perfect, or staminate and pistillate borne separately as stamens and pistils; stems always submerged ....(Pondweed Family) NAJADACEAE, p. 75.

Flowers borne in closely packed globose heads, mostly sessile along the upper parts of the leafy stems, or sometimes short-stalked, the upper heads staminate, the lower pistillate, becoming bur-like in fruit; aquatic or marsh plants with erect or floating stems ....(Bur-reed Family) SPARGANIACEAE, p. 77.

Terrestrial plants, of wet or dry habitats, the stems erect, not submerged except sometimes at the base.

Flowers without showy perianth, or if perianth showy, then with more than one pistil.

Flowers with showy perianth composed of 3 white or pinkish petal-like segments subtended by 3 outer green segments, with several to many stamens and pistils (seed-like carpels); plants with one to several leafless, usually branched stems arising from a basal cluster of leaves; marshes or low water ....(Water-plantain Family) ALISMACEAE, p. 77.

Flowers greenish, without showy perianth, bearing a single pistil which develops into a seed-like fruit, several seed-like sections (*Scheuchzeriaceae*), or into a capsule (*Juncaceae*); stamens mostly 3 or 6.

Fruits splitting into 3 to 6 seed-like sections; flowers with 6 greenish perianth segments soon falling; flowering stems slender, 10 to 70 cm high; plants of cold bogs ....(Arrow-grass Family) SCHEUCHZERIACEAE, p. 78.

Fruits not splitting into sections, becoming a single seed-like fruit or a several-seeded capsule; leaves with a free blade usually linear and "grass-like" and a sheathing lower portion closely covering the stem.

Fruit seedlike; perianth not evident or composed of bristles.

Stout plants 1 to 2.5 m high, with flat, sword-like leaves 0.6 to 2.5 cm wide, the lower sheathing parts enfolding each other in two ranks as in Iris; flowers tiny, closely packed in velvety spikes 10 to 30 cm long, 1 to 3 cm thick, the upper part staminate, the lower pistillate, with bristle-like perianth segments; stamens 2 to 7; pistil 1; marshes or low water ....(Cat-tail Family) TYPHACEAE, p. 78.

Plants of various habits and habitats; flowers arranged in spikelets subtended by herbaceous scales or bracts (glumes or glume-like), the spikelets solitary or clustered; stamens 1 to 3; perianth none or rudimentary; plants of moist or dry habitats.

Stems rounded (sometimes flattened) usually hollow between the nodes (except *Andropogon*); leaves with sheaths split down the side opposite the blade, or sometimes closed and tubular; fruits small grains, falling free or permanently enclosed by the inner scales (lemma and palea); moist or dry habitats ....(Grass Family) GRAMINEAE, p. 78.

Stems 3-angled or sometimes rounded, solid; leaves with closed tubular sheaths; fruits small lens-shaped or triangular seed-like achenes; wet places ....(Sedge Family) CYPERACEAE.[2]

Fruit a 3- to many-seeded capsule; perianth evident, the segments 6, glume-like; stamens 3 or 6; mostly of moist places ....(Rush Family) JUNCACEAE.[2]

Flowers with showy perianth; fruit a capsule or berry.[2]

HYDROCHARITACEAE (Vallisneriaceae)—Frog's-bit Family

KEY TO THE GENERA

Leaves small, 1 to 1.5 cm long, oblong to broadly lance-shaped, rather closely covering the stem in whorls of (2) 3 or 4, often rooting at the nodes (*Elodea*) ....(Waterweed) ANACHARIS.

[2] *Cyperaceae, Juncaceae,* and families with showy perianth will follow in future numbers.

Leaves long-linear, grass-like, 15 to 180 cm long, to about 2 cm wide, borne in a basal cluster, anchored by roots in the mud or sand ....(Tape-grass) VALLISNERIA.

ANACHARIS (*Elodea*) (Waterweed)

OCCURRENCE.—*Anacharis canadensis:* (G, RM).

VALLISNERIA (Eel-grass)

OCCURRENCE.—*Vallisneria spiralis:* (G).

NAJADACEAE—Pondweed Family

KEY TO THE GENERA

Flowers borne singly or few in the axils of more or less sheathing leaves, or at first in a membranous sheathing envelope; plants entirely submerged.
  Leaves narrowly linear or capillary, 2.5 to 7.5 cm long, 0.5 mm or less wide, the margins entire.
    Leaves alternate, with membranous sheathing bases; flowers borne on a short naked stem (rachis) which bears 2 unstalked anthers which soon drop off, and several pistils on opposite sides of the rachis, this elongating and raising the pistils to the surface until after pollination; salt or brackish waters ....(Ditch-grass) RUPPIA.
    Leaves opposite; flowers borne in a membranous sheath-like envelope, the staminate consisting of a single anther borne beside a group of usually 4 (2 to 8) pistils; fresh or brackish waters ....(Horned Pondweed) ZANNICHELLIA.
  Leaves linear, 1 to 3 cm long, 0.5 to 2 mm wide, the margins finely spine-toothed, opposite each other and crowded towards the ends of the branches; flowers solitary, the staminate consisting of a single stamen, the pistillate of a single pistil; fresh water. (*Naias*) ....(Naiad) NAJAS.
Flowers borne in short or elongate spike-like clusters, mostly on slender leafless stalks in the leaf axils or at the ends of the stems; stamens and pistils 4 in each flower; leaves alternate or the upper opposite, commonly with narrower submerged leaves and often broader floating blades ....(Pondweed) POTAMOGETON.

RUPPIA (Ditch-grass)

OCCURRENCE.—*Ruppia pectinata:* (Yl).

ZANNICHELLIA (Horned Pondweed)

OCCURRENCE.—*Zannichellia palustris:* (G).

NAJAS (Naiad)

OCCURRENCE.—*Najas flexilis:* (O).

POTAMOGETON (Pondweed)

KEY TO THE SPECIES

Leaves with at least some of the blades 1 cm or more wide, often of two kinds, submerged and floating.
  Submerged leaves oblong to oblong-lance-shaped or broader, not petioled, heart-shaped or broad-clasping at base, none specialized for floating.
    Stems round in cross-section; leaves mostly less than 12 cm long, 0.5 to 2.5 cm wide, the clasping bases completely surrounding the stems; stipules 1 to 2 cm long, soon disintegrating into fibers or disappearing.
      Leaves ovate to orbicular, usually 1 to 8 cm long; seed-like fruit 2.5 to 3 mm long ....*P. perfoliatus*.
      Leaves lance-shaped, usually 5 to 12 cm long; seed-like fruit 3.5 to 4 mm long ....var. *richardsonii*.
    Stems flattened; leaves 8 to 40 cm long, 1 to 4 cm wide, the clasping bases only half surrounding the stem; stipules white-papery, 1 to 3 cm long; seed-like fruit 4 to 5 mm long, short-beaked ....*P. praelongus*.

Submerged leaves narrowed to a sessile or petioled base, not at all clasping, commonly with some leaves specialized for floating, the floating leaves petioled.

Submerged leaves oblong-linear or elliptic to narrowly lance-shaped or reverse-lance-shaped, 3 to several-nerved.

Submerged leaves (6) 7.5 to 30 cm long, (0.2) 1 to 5 (6) cm wide; floating leaves with slender petioles; stems round in cross-section.

Floating leaves (when present) with elliptic to lance-shaped or ovate blades 4 to 12 (20) cm long, 1 to 4.5 (6) cm wide; stipules 4 to 10 cm long; submerged leaves petioled (or sessile), mostly with (7) 10 to 40 veins.

Floating leaves (when developed) with petioles usually shorter than the blades, 4 to 11 cm long; submerged leaves lance-shaped to narrowly reverse-ovate, 8 to 20 cm long, 2 to 5 cm wide, tapering to a short petiole or sessile base. (*P. lucens* of Am. auth., not L.) ....*P. illinoensis*.

Floating leaves with petioles 5 to 20 cm long, as long or longer than the blades.

Submerged leaves 6 to 20 cm long, 2 to 5 cm wide, of two kinds, the upper elliptic to ovate, the lower lance-shaped, with petioles 1 to 3.5 cm long, usually winged ....*P. amplifolius*.

Submerged leaves narrowly lance-shaped to linear, up to 30 cm long, 1 to 2 cm wide, gradually tapering into a petiole. (*P. americanus*, *P. lonchites*) ....*P. nodosus*.

Floating leaves with narrowly elliptic to somewhat spatula-shaped blades, 3 to 7 cm long, 0.8 to 2 (2.5) cm wide, gradually tapering into slender petioles; stipules 1 to 3 cm long; submerged leaves sessile, with 3 to 9 veins.

Floating leaves not always present; submerged leaves 0.8 to 2 cm wide, about as wide as floating leaves, 7- to 9-nerved; whole plant often reddish ....*P. alpinus* vars.

Floating leaves usually numerous; submerged leaves 2.5 to 4 mm wide, narrower than floating leaves, (3-) to 5-nerved; plant green ....*P. epihydrus*.

Submerged leaves 3 to 8 cm long, 3 to 10 mm wide, 3- to 7-nerved, sessile; floating leafblades narrowly to broadly elliptic, 2 to 5 cm long, about 1/4 to 1/2 as wide, more or less rounded at base, the petioles often exceeding the blades; stipules about 2 cm long; stems somewhat compressed. (*P. heterophyllus* of auth., not Schreb.) ....*P. gramineus*.

Submerged leaves narrowly linear, 1 (3)-nerved, 0.1 to 2 mm wide, as though reduced to petioles only, sometimes absent; floating leafblades elliptic to ovate.

Floating leaves 4.5 to 12 cm long, 2.4 to 6.5 cm wide, with stipules 4 to 7 cm long, sharp-pointed, free from petiole; submerged leaves soon falling or absent; seed-like achenes turgid, 3.5 to 5 mm long ....*P. natans*.

Floating leaves to 5 cm long, 0.5 to 2 cm wide, with stipules 6 to 10 cm long, blunt-pointed, free from petiole; submerged leaves present, the stipules similar but mostly adnate to petiole; achene flattened, 1 to 1.8 mm long ....*P. diversifolius*.

Leaves all linear, less than 1 cm wide, mostly not more than 0.5 cm wide, all submerged; stipules 1 to 3 (3.5) cm long.

Leaves many-nerved, 10 to 20 cm long, 2 to 8 mm wide; flowering spikes slender, often interrupted; seed-like achenes 4 to 5 mm long.

Stems strongly flattened, 1/3 mm wide, about 2/3 to 3/4 as wide as the leaves; stipules firm-papery, free from the leaf bases; leaves not clasping at base, the margins entire. (*P. compressus*) ....*P. zosteriformis*.

Stem not flattened, slender, less than 1/2 as wide as the leaves; stipules white, fibrous, adnate to the leaf bases for distance of 5 mm or more; leaves somewhat clasping at base, rather firm, the margins finely toothed ....*P. robbinsii*.

Leaves 1- to 5 (7)-nerved, mostly less than 2 mm wide; flowering spike capitate to short-cylindric, commonly interrupted; seed-like achenes not more than 4 mm long.

Leaves 5 to 15 cm long, 0.2 to 1.5 mm wide, mostly 1-nerved, with more or less pungent-pointed tips; stipules adnate to leaf bases; rhizomes (creeping rootstocks) bearing slender white tuber thickenings 1 to 2 cm long.

Seed-like fruits 2.5 to 4 mm long, beaked .... *P. pectinatus.*
Seed-like fruits less than 2 mm long, not beaked. (*P. interior*) .... *P. filiformis.*
Leaves 1.5 to 12 cm long, 0.1 to 3 mm wide, with 3 to 5 (7) nerves, with blunt or pointed tips; stipules free from leaf bases; rhizomes not tuberous; seed-like achenes less than 3 mm long.
Nodes (joints) of stems usually without glands.
Stipules rigid, with stiff bristles along margins, soon disintegrating into fibers; spikes short-cylindric .... *P. fibrillosus.*
Stipules delicate, decaying with age, but not becoming fibrous; spikes head-like .... *P. foliosus* var. *macellus.*
Nodes of stems usually with glands at bases of leaves.
Plants dark green or reddish; stipules whitish, papery, 1 to 2 cm long; leaves 1.5 to 3 mm wide, 3- to 7-nerved .... *P. obtusifolius.*
Plants light or bright green; stipules thin-transparent, 0.5 to 1.5 cm long, soon falling; leaves 0.1 to 1.5 mm wide; (1) 3-nerved. (*P. panormitanus*) .... *P. pusillus.*

OCCURRENCE.—*Potamogeton alpinus* var. *tenuifolius:* (G, Yl, RM); var. *subellipticus:* (Yl); *americanus* (see *P. nodosus*); *amplifolius:* (O, G); *compressus* (see *P. zosteriformis*); *diversifolius:* (GC); *epihydrus* (incl. var. *nuttallii:* (O, Yo, G); *fibrillosus:* (Yl); *filiformis* (incl. var. *borealis*) (*P. interior*): (MK, G, Yl); *foliosus* var. *macellus:* (Yl, GC); *gramineus* (*P. heterophyllus* of Amer. auth., not Schreb.): (O, S, G, Yl, GT, RM); *heterophyllus* (see *P. gramineus*); *illinoensis* (*P. lucens* of Amer. auth., not L.): (G, Yl); *interior* (see *P. filiformis*); *lonchites* (see *P. nodosus*); *lucens* (see *P. illinoensis*); *natans:* (O, MR, C, L, G, Yl, GT, RM, GC): *nodosus* (*P. americanus, P. lonchites*): (G, Yl, RM); *obtusifolius:* (Yl); *panormitanus* (see *P. pusillus*); *pectinatus:* (G, Yl); *perfoliatus* (incl. var. *richardsonii*): (MK, O, G, Yl); *praelongus:* (L, G, Yl); *pusillus* (incl. var. *mucronatus*): (C, G, Yl); var. *teniussimus:* (Yo, S); *richardsonii* (see *P. perfoliatus*); *robbinsii:* (O, Yl); *zosteriformis* (*P. compressus*): (G).

SPARGANIACEAE—Bur-reed Family

SPARGANIUM (Bur-reed)

KEY TO THE SPECIES

Stems rather stout, 40 to 60 cm high; leaves 40 to 100 cm long, 0.8 to 1.6 cm wide, triangular-keeled; staminate heads 4 to 8; seed-bearing heads 2 to 5, about 1.5 cm in diameter, brown or greenish-brown, short-stalked or not stalked, borne near the leaf axils or above. (*S. simplex* of Amer. authors) .... *S. multipedunculatum.*
Stems rather slender-elongated and floating, or erect or ascending and shorter; leaves flat, narrow, mostly less than 1 cm wide; staminate heads 1 to 4 (or 6); seed-bearing heads solitary or 2 to 4, mostly 5 to 10 mm in diameter, not stalked.
Stems up to 1.2 m long, usually submersed; leaves 1.5 to 5 mm wide; fruiting heads 1 to 3, at least one borne above a leaf axil, not stalked; widespread .... *S. angustifolium.*
Stems very slender, 10 to 80 cm long, floating or erect; leaves 1.5 to 8 mm wide; fruiting heads 1 to 4, 8 to 12 mm in diameter, borne in the leaf axils; infrequent in the western parks .... *S. minimum.*
OCCURRENCE.—*Sparganium angustifolium:* MK, O, MR, K, S, Yl, GT, RM, GC; *minimum:* MR, C, G, RM; *multipedunculatum* (*S. simplex* of Amer. auth.): O, MR, G, Yl, GT, RM.

ALISMACEAE—Water-plantain Family

KEY TO THE GENERA

Leafblades oblong to ovate, wedge-shaped to heart-shaped at base: flowers with carpels forming a circle in a single series on a flat receptacle; stamens 6 to 9 .... (Water-plantain) ALISMA.
Leafblades, in ours, sagittate (arrow-shaped) or sometimes lacking; flowers with carpels numerous, aggregated into a globose head on a convex receptacle; stamens numerous .... (Arrow-head) SAGITTARIA.

ALISMA (Water-plantain)

OCCURRENCE.—*Alisma subcordatum:* GC; *triviale* (*A. plantago-aquatica, A. brevipes*): G, RM, GC.

SAGITTARIA (Arrow-head)

OCCURRENCE.—*Sagittaria cuneata* (*S. arifolia*): G, Yl, GT, RM.

SCHEUCHZERIACEAE (Juncaginaceae)—Arrow-grass Family

KEY TO THE GENERA

Leaves all basal; flowering stems 10 to 70 cm high ....(Arrow-grass) TRIGLOCHIN.
Stems leafy; flowering stems to 40 cm high ....SCHEUCHZERIA.

TRIGLOCHIN (Arrow-grass)

KEY TO THE SPECIES

Fruits linear or somewhat club-shaped, tapering to a narrow base, 5 to 8 mm long, composed of 3 carpels (seed-like sections); stems slender, 10 to 30 cm high; leaves less than 3 mm wide; flowering spike usually appearing crowded ....*T. palustris.*
Fruits oblong or ovoid, rounded at base, 5 to 6 mm long, 2 to 4 mm thick; carpels mostly 6 (or 3).
  Stems slender, mostly 10 to 30 cm high; rootstocks slender, elongate; inland parks.
    Stems slender; rootstocks not particularly fibrous-covered ....*T. concinna.*
    Stems somewhat stouter than the species, with fibrous sheaths of old leaves covering rootstocks ....var. *debilis.*
  Stems stout, 10 to 70 cm high, with stout short rootstocks covered with old leaf sheaths; northwest coast ....*T. maritima.*

OCCURRENCE.—*Triglochin concinna* (and. var. *debilis*): K, S, Yl (reported), B; *maritima:* O, Yl (reported); *palustris:* MK, K, S, Yl, RM.

SCHEUCHZERIA

OCCURRENCE.—*Scheuchzeria palustris:* G.

TYPHACEAE—Cat-tail Family

TYPHA (Cat-tail)

KEY TO THE SPECIES

Stems stout, 1 to 2 m high; lower leaves 1 to 2.5 cm wide; flowering spike 10 to 30 cm long, 2 to 3 cm thick, dark brown, the staminate and pistillate parts usually joined ....*T. latifolia.*
Stems generally more slender, commonly not as tall; lower leaves narrower, to about 1 cm wide; flowering spike more slender, lighter brown, with staminate and pistillate portions separated, sometimes 5 cm apart ....*T. angustifolia.*

OCCURRENCE.—*Typha angustifolia:* Yl, Z, GC; *latifolia:* MR, G, Yl, GT, RM, Z.

GRAMINEAE—Grass Family

It would be impossible to give concise clear statements distinguishing between members of the grass family without resorting to the use of certain semi-technical terms commonly used by botanists to designate the vegetative and floral parts of grasses. Characteristically, grass stems (*culms*) are hollow except at the solid joints (*nodes*). Rarely, the stems between the nodes are also solid.

The leaf is composed of a long cylindrical portion (*sheath*) which surrounds the stem as a sheath, and a spreading *blade*. At the junction of the sheath and blade is the *ligule*, which is a membranous tongue-like extension from the inside lining of the sheath. It may be reduced to a fringe of hairs

or to a hardened ring. At this point also there may be a pair of expanded ear-like lobes (*auricles*) at the base of the blade, one on either side.

The structure most evident as an important unit for the identification of grasses is known as the little spike (*spikelet*). It is composed of one or more flowers (*florets*) on a very short stem (*rachilla*) and subtended below by a pair of small leaf-like bracts (*glumes*). Each floret is usually a *perfect* flower, containing the essential parts for the production of the fruit or *grain*. These are the *stamens* (usually 3), with sac-like *anthers* which produce pollen, and a *pistil* consisting of a basal *ovary* and 2 feathery *stigmas*. After fertilization, the ovary matures into the *grain*. The stamens and pistil units are generally enclosed by 2 floral bracts, an outer *lemma* and an inner *palea*. This latter may be considerably reduced or sometimes lacking altogether. In some species one or more florets may be sterile or imperfect, without one or both essential flower parts, or in some cases, reduced to a lemma only. Glumes or lemmas may be variously awned with bristle-like appendages. Variations and modifications in the grass spikelets and florets are important characteristics used in distinguishing between the different genera and species.

KEY TO THE TRIBES

Spikelets in groups of 2 or 3 falling together, sometimes with section of flowering stem attached, the spikelets of a group generally of 2 kinds, one perfect and one or 2 staminate or reduced.
  Spikelets in pairs, the perfect unstalked and awned, the staminate (or rudiment) stalked and awnless, or in one species both spikelets of a pair perfect and awnless but unequally stalked; southwest .... Tribe ANDROPOGONEAE, p. 80.
  Spikelets in groups of 3, the central spikelet perfect, the 2 lateral spikelets staminate or reduced to rudiments, all awned.
    Perfect and staminate spikelets both unstalked, the perfect with glumes 3-awned, the staminate with glumes 1-awned, the group long-hairy at base; axis of flower cluster continuous, not breaking to pieces when groups of spikelets fall; southwest deserts .... *Hilaria* of Tribe ZOYSIEAE, p. 81.
    Perfect spikelet unstalked, the 2 lateral spikelets stalked or often reduced to mere awns; spikelet group not hairy at base; axis of flower cluster generally breaking up at the joints, each section remaining attached below group of spikelets; some species widely distributed .... *Hordeum* of Tribe HORDEAE, p. 82.
Spikelets usually borne singly, or if appearing in groups of 2 or more, of the same kind and not falling together as a unit.
  Spikelets not stalked.
    Spikelets borne singly or in groups of 2 to several on opposite sides of the simple unbranched flowering stem, the flower clusters usually appearing symmetrical, not one-sided .... Tribe HORDEAE, p. 81.
    Spikelets borne more or less in 2 rows on one side of a usually flattened or triangular axis, thus the flower cluster or its branches appear one-sided; spikelets in ours, with 1 perfect floret (except in *Munroa*).
      Spikelets flattened, with glumes attached on narrow edge; falling with or without glumes attached; sterile florets, if present, above the perfect floret which is not hardened .... Tribe CHLORIDEAE, p. 86.
      Spikelets flattened so that glumes are borne on broad sides, falling from stems with glumes attached; sterile lemma below perfect floret, similar to second glume, each about as long and broad as the hardened perfect floret and together enclosing it like 2 glumes; first glume shorter .... Tribe PANICEAE, p. 87.
  Spikelets stalked.
    Spikelets flattened so that glumes are attached on broad side; glumes unequal, the first shorter than the spikelet, the second as long as the spikelet and similar in appearance to a sterile lemma borne opposite it below the fertile floret; perfect

floret somewhat hardened; spikelets falling entire with glumes attached .... Tribe PANICEAE, p. 87.

Spikelets not flattened or tending to be flattened so that glumes are attached on the narrower side; sterile florets, if present, not similar to the glumes, generally borne above the perfect florets (except in the tribe Phalarideae); perfect florets not generally decidedly hardened.

Glumes as long or longer than first lemma, usually as long or longer than entire spikelet; spikelets usually breaking away above the glumes, but in some genera falling with glumes attached.

Spikelets 1-flowered (rarely some 2-flowered in *Muhlenbergia*); lemmas awned or awnless ....Tribe AGROSTIDEAE, p. 89.

Spikelets 2- or more-flowered.

Spikelets 3-flowered, the upper perfect floret nearly smooth, unawned; lower imperfect florets with lemmas hairy, awnless or awned from below the tip ....Tribe PHALARIDEAE, p. 98.

Spikelets 2- to several-flowered, the florets alike, the lemmas awned from the back or from between the teeth of a 2-toothed tip, or sometimes awnless ....Tribe AVENEAE, p. 98.

Glumes mostly shorter than the first floret; spikelets usually several-flowered, usually breaking up above the glumes; lemmas awnless or awned from the tips ....Tribe FESTUCEAE, p. 101.

Tribe ANDROPOGONEAE

KEY TO THE GENERA

Spikelets alike, awnless, all perfect (with stamens and pistil), surrounded by a copious tuft of soft silky hairs, those of a pair on stalks of unequal length; flower clusters narrow and spike-like, with a continuous axis which does not break at the joints; perennial; stems 90 to 150 cm high ....(Satin-tail) *Imperata brevifolia.*

Spikelets of a pair mostly unlike; one floret perfect, awned, not stalked; second floret sterile, awnless, stalked; flower cluster of one to several narrow spike-like flowering branches borne at or near the top of the stem; flowering stems breaking at the joints, the sections falling attached to pair of spikelets.

Stem of flowering branch (rachis) breaking so that stalk-like sections remain attached below spikelet groups; awn of perfect spikelet strong, densely hairy, 3 to 12 cm long, bent and flexuous, usually tangled; stems 20 to 80 cm high, the spike-like flowering clusters borne singly at top of stem ....(Tanglehead) *Heteropogon contortus.*

Stem of flowering branch (rachis) breaking so that spikelet groups appear unstalked; awn of perfect spikelet not usually exceeding 2 cm in length, slender and delicate or soon falling; spike-like flower clusters borne singly or in clusters of several; stems 40 to 150 (300) cm high.

Flower clusters spike-like or composed of spike-like branches, mostly more or less silky because of long white silky hairs on the short axis of the spikelet (rachilla); awn delicate, smooth; our perennials ....(Beardgrass) ANDROPOGON.

Flower clusters branched, the branches short and loose, not appearing spike-like, not long-silky; awns of perfect spikelets 1 to 1.5 cm long, bent; annual or perennial ....SORGHUM; *Sorghastrum.*

IMPERATA (Satin-tail)

OCCURRENCE.—*Imperata brevifolia* (*I. hookeri*): GC.

HETEROPOGON (Tanglehead)

OCCURRENCE.—*Heteropogon contortus:* GC.

ANDROPOGON (Beardgrass)

KEY TO THE SPECIES

Spike-like flowering stems (racemes) 2 to several on a stem surrounded by a leaf-like sheathing bract, these borne individually or aggregate into dense leafy clusters; stems 50 to 150 cm high.

Racemes aggregate into a dense silky cluster; stalked spikelet reduced to a single glume or sometimes even the stalk lacking; unstalked perfect spikelet with awn 1 to 1.5 cm long .... *A. glomeratus.*
Racemes usually 2 or 3 at top of stem (resembling a turkey foot); stalked imperfect spikelet stamen-bearing; awnless unstalked perfect spikelet with awn 5 mm long, or awn lacking .... *A. gerardii; A. hallii.*
Spike-like flowering stems (racemes) several to numerous, forming a leafless cluster; stems 40 to 120 (130) cm high.
Flower clusters more or less fan-shaped, the several to many racemes on a relatively short axis, mostly less than 5 cm long; perfect spikelets about 5 to 6 mm long; awn 1.5 to 2 cm long .... *A. barbinodis.*
Flower clusters oblong, with numerous racemes on a relatively long axis about 4 to 8 cm long; perfect spikelets about 4 mm long; awn 1 to 1.5 cm long ....*A. saccharoides.*

OCCURRENCE.—*Andropogon barbinodis:* GC; *gerardii:* Yl; *glomeratus:* GC; *hallii:* Yl; *hirtiflorus:* GC; *saccharoides:* Z (reported); *scoparius* (racemes solitary): Yl.

SORGHUM (Johnson Grass, Sudan Grass)

KEY TO THE SPECIES

Plants perennial; stems 50 to 150 cm high .... (Johnson Grass) *S. halepense.*
Plants annual; stems 150 to 300 cm high .... (Sudan Grass) *S. sudanense.*

OCCURRENCE.—*Sorghum halepense:* Z, GC; *sudanense:* GC.

SORGHASTRUM

OCCURRENCE.—*Sorghastrum nutans:* Yl.

Tribe ZOYSIAE (Nazieae)

HILARIA (Galleta)

OCCURRENCE.—*Hilaria jamesii:* Yl, RM, MV, Z, GC.

Tribe HORDEAE

KEY TO THE GENERA

Flower clusters commonly bristly, the axis usually readily breaking apart at the joints each segment remaining attached as a short stalk to a group of 2 or more spikelets; at least the fertile lemmas awned.
Spikelets 1-flowered, borne in 3's at the joints, the middle one usually perfect, not stalked, the two outer stalked, imperfect or reduced to bristles; glumes narrow and bristle-like, standing in front of the spikelets .... (Barley) HORDEUM.
Spikelets alike, 2- to few-flowered, borne usually in pairs at the joints; glumes narrow or bristle-like, with 1 to 3 prominent nerves extending into 1 to several awns .... (Squirreltail) SITANION.
Flower clusters not bristly, the axis not usually readily breaking at the joints, if bristly or breaking at the joints, then the spikelets solitary (see 2 species of *Agropyron*).
Flower clusters appearing flattened due to flattened spikelets which are borne singly and rather far apart on opposite sides of the axis with the narrow edge against the rachis; spikelets with only 1 glume, this borne outward to the spikelet .... (Ryegrass) LOLIUM.
Flower clusters not appearing flattened (somewhat compressed in *Agropyron desertorum* but the spikelets closely crowded); spikelets with both glumes present, placed more or less with flat side to the rachis.
Spikelets mostly in 2's (3's or 4's) or sometimes solitary at the joints; perennials .... (Wild Rye) ELYMUS.
Spikelets borne solitary at the joints or rarely with some of the spikelets paired in *Agropyron.*
Plants perennial; spikelets 2- to several-flowered, awned or awnless; some species widespread and common in the western parks .... (Wheatgrass) AGROPYRON.
Plants annual; escaped from cultivation and rare in the western parks.
Spikelets 2- to 5-flowered; glumes ovate, 3-nerved; lemmas awned or awnless; flower cluster stout, erect .... (Wheat) *Triticum aestivum.*

Spikelets 2-flowered; glumes bristle-like, 1-nerved; lemmas long-awned; flower cluster rather slender, nodding ....(Rye) *Secale cereale.*

HORDEUM (Barley)

KEY TO THE SPECIES

Awns 1.5 to 6 (8) cm long; flower clusters 5 to 10 cm long; stems 15 to 60 cm high; leafblades 2 to 6 mm wide.
  Tufted perennials; flower clusters nodding, often purplish; widespread species.
    Awns 1.5 to 6 (8) cm long ....(Foxtail) *H. jubatum.*
    Awns 1.5 to 3.5 cm long ....var. *caespitosum.*
  Annual with stems branching at base; flower clusters more erect, the awns 2 to 4 cm long; southwest. (*H. murinum* of our area.) ....*H. leporinum.*
Awns mostly less than 1.5 cm long.
  Flower clusters, including awns, generally less than 10 mm wide, about 10 times as long as broad; awns 0.5 to 1 cm long; tufted perennial 20 to 70 (100) cm high; leafblades 3 to 8 mm wide; widespread species. (*H. nodosum* of our area.) ....*H. brachyantherum.*
  Flower clusters, including awns, generally 10 to 15 mm wide, about 1½ to 5 times as long as broad; awns 0.8 to 1.5 cm long; annuals with stems 10 to 40 cm high; leafblades 2 to 6 mm wide; southern Rocky Mountains and southwest.
    Flower clusters 2 to 7 cm long, the axis breaking up at maturity; glumes of fertile spikelets broadened above base ....*H. pusillum.*
    Flower clusters 1.5 to 3 cm long, the axis not readily breaking up; glumes of fertile spikelets bristle-like ....*H. hystrix.*

OCCURRENCE.—*Hordeum brachyantherum* (*H. nodosum* of our area): O, MR, C, L, Yo, K, S, G, Yl, GT, RM, Z, GC; *hystrix:* GC; *jubatum:* MK, MR, S, G, Yl, GT, RM, MV, B, Z, GC; var. *caespitosum:* Yl; *leporinum* (*H. murinum* of our area): K, Z, GC; *montanense* (*H. jubatum* X *Elymus virginicus*): Yl; *pusillum:* Yl, RM, MV.

SITANION (Squirreltail)

KEY TO THE SPECIES

Stems 60 to 100 cm high; flower cluster 8 to 20 cm long, much longer than broad; glumes narrowly lance-shaped, 2- to 4-nerved; awn of lemma 4 to 5 cm long; leafblades 2 to 8 mm wide; Pacific slope ....*S. hanseni.*
Stems 10 to 60 cm high; (2) 3 to 10 cm long; flower cluster, including awns, as broad as long or broader; glumes bristle-like, mostly 1-nerved; awn of lemma (2) 3 to 10 cm long; leafblades rarely more than 4 mm wide.
  Flower clusters 3 to 10 cm long; glumes split into at least 3 awned parts; southwest ....*S. jubatum.*
  Flower clusters 2 to 7 (10) cm long; glumes not split or split into 2 parts; most widespread species in western parks ....*S. hystrix.*

OCCURRENCE.—*Sitanion hanseni:* O, MR, C, K, S; *hystrix:* O, MR, C, L, Yo, K, S, G, Yl, GT, RM, MV, B, Z, GC; *jubatum:* GC.

LOLIUM (Ryegrass)

KEY TO THE SPECIES

Glume shorter than the spikelet; plants perennial.
  Stems 30 to 60 cm high; lemmas awnless; sheaths without ear-like lobes (auricles) at junction with blade or these very tiny; widespread species ....*L. perenne.*
  Stems to 90 cm high; at least the upper lemmas awned; sheaths with prominent ear-like lobes (auricles) at junction with blade; northwest ....(Italian Ryegrass) *L. multiflorum.*
Glume as long or longer than spikelet; lemmas awned ....(Darnel) *L. temulentum.*

OCCURRENCE.—*Lolium multiflorum:* O, MR; *perenne:* O, MR, C, Yo, Yl, B, GC; *temulentum:* Yo, S.

ELYMUS (Wild Rye)

KEY TO THE SPECIES

Lemmas awnless or with short awns mostly less than 5 mm long.
  Flower clusters thick, sometimes somewhat branched, the spikelets in 2's to 4's at the joints; glumes awnless or barely awn-tipped; lemmas more or less hairy to roughish-hairy.
    Stems 50 to 100 cm high; flower clusters 5 to 12 cm long; spikelets 10 to 12 mm long; glumes very narrow; lemmas somewhat purplish or grayish, mostly with awns 1 to 4 mm long; plants with slender creeping underground stems (rhizomes) .... *E. hirtiflorus; E. innovatus.*
    Stems 60 to 120 (200) cm high; flower clusters 7 to 25 cm long; spikelets 12 to 25 mm long; lemmas pale, awnless or barely awn-tipped.
      Stems to about 120 cm high, from slender widely creeping rhizomes; glumes lance-shaped, flat, many-nerved; coastal, northwest .... *E. mollis.*
      Stems to 200 (or more) cm high, generally without creeping rhizomes or these short and thick; glumes very narrow; Rocky Mountains ....(*E. condensatus* of the interior) *E. cinereus.*
  Flower clusters slender, 5 to 15 cm long; spikelets in 2's or solitary at the joints, or often both in 2's and solitary in the same flower cluster; lemmas not hairy.
    Stems 60 to 120 cm high, from extensively creeping rhizomes; leafblades 2 to 6 mm wide; glumes very narrow, firm, awn-tipped; lemmas purplish to tawny or brownish, awn-tipped; rare, Rocky Mountains .... *E. triticoides.*
    Stems 30 to 60 (100) cm high, in loose tufts without creeping rhizomes; glumes pointed or awn-tipped.
      Glumes flat, 1 to 2 mm wide, strongly 3-nerved; lemmas barely awn-tipped or with awns to 4 mm; leafblades flat, 5 to 10 mm wide; northwest .... *E. virescens.*
      Glumes very narrow; leafblades mostly less than 5 mm wide, the margins inrolled or becoming so; most of the spikelets solitary at the joints; rare in the western parks.
        Lemmas awnless or merely awn-tipped; stems densely tufted, the leaves mostly basal; southwest .... *E. salinus.*
        Lemmas short-awned with awns mostly 2 or more mm long; stems loosely tufted or scattered, the leaves not mostly basal.
          Plants without creeping rhizomes; awns of lemmas to 5 mm long; Rocky Mountains .... *E. ambiguus.*
          Plants with long extensively creeping rhizomes which are valuable as sand binders in erosion control; awns of lemmas very short to 14 mm long; river banks and alkali flats or rocky slopes; southwest .... *E. simplex.*
Lemmas distinctly awned, the awns mostly more than 5 mm long.
  Glumes very narrow, only the midnerve distinct; lemmas with straight awns or nearly awnless; flower clusters slender, 5 to 7 mm thick; stems 50 to 90 (100) cm high; leafblades mostly less than 5 mm wide.
    Stems from long creeping rhizomes; flower clusters 5 to 20 cm long; spikelets mostly solitary at the joints; lemmas awn-pointed or with awns to 14 mm long; valuable in erosion control; southwest .... *E. simplex.*
    Stems densely tufted, without creeping rhizomes; flower clusters 4 to 12 cm long; spikelets mostly in 2's at the joints; lemmas with awns 1 to 2 cm long; scattered distribution .... *E. macounii.*
  Glumes somewhat broadened above the base, distinctly 2- to several-nerved; lemmas with awns 1 to 3 cm long; flower clusters mostly 8 to 10 (or more) mm wide; leafblades (5) 8 to 20 mm wide; stems 50 to 150 cm high, solitary or loosely to densely tufted.
    Spikelets commonly in 3's or 4's at the joint; lemmas more or less hairy with rather coarse hairs; awns 2 to 3 cm long, divergent when dry; glumes somewhat hardened at base, awned; flower clusters nodding or drooping, 10 to 25 cm long; stems 60 to 150 cm high; Rocky Mountains and southwest .... *E. canadensis.*
    Spikelets commonly in 2's at the joints; lemmas smooth or somewhat hairy; awns 1 to 2 cm long; glumes thin, flat, not hardened at base; flower clusters erect or nodding; stems 50 to 120 (140) cm high.

Lemmas smooth or roughish, not hairy, the awns straight; glumes awnless or merely awn-pointed; flower clusters erect or nodding, 5 to 20 cm long; stems to 120 cm high; most widespread species in the western parks ....*E. glaucus.*

Lemmas long-hairy along the upper margins and sometimes coarsely hairy over back, with flexuous or divergent awns; glumes awned; flower clusters nodding or drooping, 10 to 15 cm long; stems to 140 cm high; northwest ......*E. hirsutus.*

OCCURRENCE.—*Elymus ambiguus:* RM; var. *strigosus:* Yl; *canadensis:* G, Yl, Z, GC; *cinereus* (*E. condensatus* of the interior): S, G, Yl, GT, RM; *glaucus:* O, MR, C, L, Yo, K, S, G, Yl, RM, Z, GC; *hirsutus:* O; *hirtiflorus:* Yl; *innovatus:* MK, Yl; *macounii:* C, Yl, MV; *mollis:* O; *salinus:* GC; *simplex:* B; *triticoides:* G; *virescens:* O, MR.

AGROPYRON (Wheatgrass)

KEY TO THE SPECIES

Lemmas awnless or with awns less than 10 mm long.

Spikelets strongly flattened, crowded on the stem, somewhat spreading so the flower cluster appears as a bristly spike resembling a species of foxtail (*Hordeum*); lemmas about 6 mm long, these and the glumes with short slightly bent awns 2 to 3 mm long; stems tufted, 25 to 100 cm high; introduced species not common in western parks; mostly southwest ....*A. desertorum.*

Spikelets not strongly flattened, somewhat overlapping or widely spaced, not closely packed into a compact bristly spike; lemmas 8 to 10 mm long, short-awned or awnless.

At least the first glume narrow, the margins scarcely membranous, mostly not more than half as long as the spikelet; mostly Rocky Mountains and southwest (except *A. sericeum*).

Glumes gradually narrowed to awn points; lemmas awnless to distinctly short-awned; plants with creeping underground stems (rhizomes).

Lemmas not hairy, or sometimes finely hairy only at base in *A. smithii;* anthers 3 to 5 mm long; widespread species.

Stems 30 to 60 cm high; leafblades rather stiff, narrow, the margins inrolled ....*A. smithii.*

Stems 50 to 100 cm high; leafblades lax, flat, 6 to 10 mm wide ....(Quackgrass) *A. repens.*

Lemmas finely hairy over back; anthers about 1 mm long; stems about 30 to 80 cm high; leafblades flat, about 4 to 8 mm wide; Alaska ....*A. sericeum.*

Glumes abruptly pointed, not tapering to awn point; lemmas awnless or with slight awn tip; leafblades narrow, mostly with the margins inrolled; stems 40 to 100 cm high, with or without rhizomes.

Plants without underground creeping rhizomes; spikelets widely spaced, about as long as one internode; lemmas not hairy ....*A. inerme.*

Plants with creeping rhizomes; spikelets closer together, about as long as two internode sections.

Lemmas not hairy; southwest ....*A. riparium.*

Lemmas hairy; Rocky Mountains ....*A. dasystachyum.*

Glumes broad, more than half to nearly as long as the spikelets; spikelets not noticeably flattened, often purplish; glumes and lemmas awnless or awn-tipped; anthers 1 to 3 (4) mm long; stems 20 to 100 cm high.

Plants with creeping rhizomes or these sometimes lacking; stems 30 to 90 cm high; spikelets with the axis between the florets softly hairy; not common ....*A. pseudorepens.*

Plants usually without creeping rhizomes; axis of spikelets nearly smooth or merely roughish.

Glumes not thin-margined; lemmas smooth; very variable species with stems 20 to 100 cm high; flower cluster 10 to 25 cm long, the spikelets rather far apart, scarcely overlapping; widespread ....*A. trachycaulum.*

Glumes thin-margined especially on the upper part; lemmas smooth or hairy.

Stems 50 to 90 cm high; flower cluster about 10 to 14 cm long, the spikelets fairly distant, nearly as long as two internode sections; Alaska ....*A. alaskanum.*

Stems 20 to 60 cm high; flower clusters to about 10 cm long, the spikelets closely overlapping; Rocky Mountains to Alaska .... *A. latiglume.*

Lemmas distinctly awned, the awns (0.5) 1 cm or more long; plants mostly without creeping underground stems (rhizomes).

Awns nearly straight, not divergent when dry; stems 50 to 100 (150) cm high, erect; axis of flower clusters generally continuous (sometimes tardily breaking up).

Flower clusters generally green or pale; glumes awnless or with awns less than 1 cm long; awns of lemmas (0.5) 1 to 3 cm long; Pacific slope and Rocky Mountains, middle elevations.

Flower clusters 6 to 15 cm long; spikelets rather closely overlapping; glumes broad, short-awned; widespread. (*A. caninum* as to ours) .... *A. subsecundum.*

Flower clusters 10 to 25 (30) cm long; spikelets rather far apart; glumes narrow, blunt-pointed, awnless; not common, California ....*A. parishii* var. *laeve.*

Flower clusters commonly purplish, 8 to 15 cm long; glumes narrow or wider, with awns 1 to 4 (5) cm long and sometimes short awns near base of main awn; awns of lemmas 2 to 5 cm long; rare, California .... *A. saundersii.*

Awns divergent when dry; stems tufted, often in large clumps.

Axis of flower clusters generally continuous, not readily breaking up into sections; glumes rather broad, 3- to 5-nerved; spikelets rather far apart on the axis or loosely overlapping.

Stems erect, mostly 50 to 100 cm high; flower clusters 5 to 15 (40) cm long; glumes awn-pointed or with divergent awns; Rocky Mountain parks.

Plants with creeping rhizomes; glumes awn-pointed; awns of lemmas 1 to 1.5 cm long .... *A. albicans; A. griffithsii.*

Plants without creeping rhizomes.

Spikelets scarcely overlapping; glumes about ½ as long as the spikelet, rarely short-awned; awns of lemmas mostly 1 to 2 cm long; anthers 3 to 6 mm long .... *A. spicatum.*

Spikelets somewhat overlapping; glumes about ⅔ as long as the spikelets, with awns 2 to 8 mm long; awns of lemmas 1 to 3.5 (4) cm long, often awn-toothed at base of main awn .... *A. bakeri.*

Stems tending to be prostrate and curved upwards at the base, 30 to 50 cm high; flower clusters 4 to 7 cm long; spikelets rather far apart; glumes with straight awns 5 mm long; awns of lemmas 1.5 to 2.5 cm long; upper elevations, Sierra Nevada parks .... *A. pringlei.*

Axis of flower clusters finally breaking up into sections at the joints with a spikelet attached to each section; glumes narrow, 1- or 2 (3)-nerved, awned; not common, Rocky Mountains and southwest.

Stems erect, 30 to 80 cm high; flower clusters 5 to 12 cm long; awns of lemmas 2 to 5 cm long, sometimes with 1 or 2 short awns at base; middle elevations .... *A. saxicola.*

Stems spreading or prostrate, 20 to 40 cm long; flower clusters 3 to 7 cm long; awns of lemmas 1.5 to 2.5 cm long; high elevations .... *A. scribneri.*

OCCURRENCE.—*Agropyron alaskanum:* MK; *albicans:* Yl, GT; *bakeri:* RM; *dasystachyum:* G, Yl, GT; *desertorum* (*A. cristatum,* as to ours): G, Yl, MV, B; *griffithsii:* Yl, RM; *inerme:* G, Yl, Z; *latiglume:* MK, G, GT; *parishii* var. *laeve:* S (reported); *pringlei:* Yo, K, S; *pseudorepens:* Yl, GC; *repens:* O, C, Yl, B, Z, GC; *riparium:* Yl, Z; *saundersii:* Yo, K, S; *saxicola:* Yl; *scribneri:* Yl, B; *sericeum:* MK; *smithii:* MR, K, G, Yl, RM, MV, Z, GC; var. *molle:* GC; *spicatum:* Yl, GT; *subsecundum* (*A. caninum,* as to ours): L, Yo, S, G, Yl, GT, GC; var. *andinum:* Yl; *trachycaulum* (incl. *A. tenerum, A. violaceum, A. pauciflorum, A. biflorum*): MR, K, S, G, Yl, GT, RM, MV, B, Z, GC.

TRITICUM (Wheat)

OCCURRENCE.—*Triticum aestivum:* G.

SECALE (Rye)

OCCURRENCE.—*Secale cereale:* Yl, GC.

Tribe CHLORIDEAE

KEY TO THE GENERA

Flowering branches (spikes) arising from about the same position at the top of the stem; florets falling from spikelets leaving empty glumes attached to stems.

Spikes much reduced (only one or 2 spikelets), borne in small head-like clusters of about 3 enclosed by broad sheaths of short leaves; spikelets with 2 to 4 perfect flowers .... (False Buffalo-grass) *Munroa squarrosa.*

Spikes 2 to 8 cm long, the spikelets numerous and crowded on the stems, several borne at the top of the stem; stem leaves some distance below the flower cluster, not surrounding it as a sheath at maturity; spikelets 1-flowered (except for reduced upper floret).

Annual with stems 40 to 60 (100) cm tall; spikes several, 8-10 or more, borne more or less erect from the top of the stem like a feather duster; lemma hairy on upper margins with dense tuft of hairs 2 to 4 mm long; awns on lemma and rudiment about 5 to 10 mm long ....(Feather Finger-grass) *Chloris virgata.*

Perennial with stems 10 to 40 cm tall from extensively creeping rhizomes; spikes 4 or 5, widely spreading from the top of the stem like the ribs of an umbrella; spikelets with lemma nearly glabrous, awnless, without rudimentary floret above perfect floret ....(Bermuda Grass) *Cynodon dactylon.*

Flowering branches (spikes) borne scattered along the length of the main axis of the flower cluster.

Flowering branches (spikes 2 to 10 cm long, the spikelets borne closely appressed and rather separated along the side of the 3-angled stem (rachis); spikelets about 4 mm long, 1-flowered, the rachilla not prolonged beyond the floret; florets breaking away from the spikelets above the glumes, leaving empty glumes attached to stems; a grass of the dry plains, reported from our area ....(Tumble-grass) *Schedonnardus paniculatus.*

Flowering branches (spikes) mostly about 1 to 4 (5) cm long, the spikelets mostly closely packed in 2 rows on one side of the rachis; spikelets breaking away from the flower cluster below the glumes, falling entire.

Spikes 1 or 2 cm (or less) long, crowded in groups of 1 to few on short erect branches of the flower cluster; spikelets about 3 mm long, as broad as long, the glumes alike, broad and arched or curved on the back, boat-shaped with pointed tips, appearing somewhat wrinkled; annual with stems 30 to 100 cm high; Rocky Mountains to Alaska ....(American Slough-grass) *Beckmannia syzigachne.*

Spikes 1 to 5 cm long, seevral borne singly along the main axis of the flower cluster (sometimes only 1 to 3); spikelets mostly 2.5 to 5 (8) mm long, the glumes unequal, not arched on back, tapering to narrow or pointed tips.

Spikelets 1-flowered, 6 to 8 mm long, awnless, without rudimentary florets; spikes 2 to 4 cm long, 4 to 8 closely appressed to the main axis of the flower cluster; lemma obscurely 3-nerved, awnless; stout perennial with stems 60 to 100 cm high; alkali meadows; rare in our area ....(Alkali Cord-grass) *Spartina gracilis.*

Spikelets with one perfect floret and rudiments of one or more florets above; lemma 3-nerved, the nerves ending in awns or awn points; rudimentary floret usually 3-awned; annuals or perennials with stems 10 to 80 cm high; mostly southwest ....(Grama-grass) BOUTELOUA.

MUNROA (False Buffalo-grass)

OCCURRENCE.—*Munroa squarrosa:* Yl, GC.

CHLORIS (Finger-grass)

OCCURRENCE.—*Chloris virgata:* Z, GC.

CYNODON (Bermuda Grass)

OCCURRENCE.—*Cynodon dactylon:* Yo, S, GC.

SCHEDONNARDUS (Tumble-grass)

OCCURRENCE.—*Schedonnardus paniculatus:* Yl (reported).

BECKMANNIA (Slough-grass)

OCCURRENCE.—*Beckmannia syzigachne* (*B. erucaeformis* as to American plants): MK, G, Yl, GT, RM, GC.

SPARTINA (Cord-grass)

OCCURRENCE.—*Spartina gracilis:* Yl.

BUCHLOE (Buffalo-grass)

OCCURRENCE.—*Buchloe dactyloides:* Yl. (Upland, Great Plains sod grass.)

BOUTELOUA (Grama-grass)

KEY TO THE SPECIES

Flowering spikes several to many on the main stem axis, mostly (0.7) 1 to 2 cm long, bearing only 2 to 8 spikelets rather loosely arranged on the rachis.

Spikes mostly 8 to 14, becoming reflexed, soon falling from stem; spikelets 2 to 4 in a spike; awns about 5 mm long; annual plants with slender stems 10 to 30 cm tall ....(Needle Grama) *B. aristidoides.*

Spikes mostly 30 to 50, spreading or drooping on short stems usually twisted to one side of the main axis; spikelets (2) 4 to 8, awnless or the awns small and inconspicuous; tufted perennial with scaly rhizomes, the stems usually 50 to 80 cm tall ....(Side-oats Grama) *B. curtipendula.*

Flowering spikes mostly less than 8 along the main axis, 1 to 5 cm long, bearing 12 or more (usually more) spikelets closely packed on the rachis.

Spikelets 12 to 20 in a spike, 7 to 10 mm long; spikes 3 to 8 on the stem; tufted perennials; lemmas hairy on lower part only.

Stems 40 to 60 cm tall, densely white-woolly; awns of fertile lemma mostly about 1.5 to 3 mm long, those of rudiments 4 to 8 mm long ....(Black Grama) *B. eriopoda.*

Stems rather delicate, 10 to 20 cm tall, glabrous; awns mostly about 5 mm long, winged towards base ....(Red Grama) *B. trifida.*

Spikelets numerous (25 to 80), 2.5 to 5 mm long; fertile lemmas long hairy.

Spikes 4 to 7 along the stem, 1 to 2 cm long; awns very short, usually less than 2 mm long; annual with stems to 30 cm tall, often forming mats ....(Six-weeks Grama) *B. barbata.*

Spikes mostly 2 (sometimes 1 to 3 or 4), 2.5 to 5 cm long; awns 1 to 3 mm long, or those of rudimentary floret to 5 mm long; tufted perennials (or annual) with stems 25 to 60 cm tall (sometimes much shorter) .... (Mat Grama) *B. simplex;* (Hairy Grama) *B. hirsuta;* (Blue Grama) *B. gracilis.*

OCCURRENCE.—*Bouteloua aristidoides:* GC; *barbata:* GC; *curtipendula:* Yl, Z, GC; *eriopoda:* GC; *gracilis:* Yl, RM, MV, B, Z, GC; *hirsuta:* GC; *simplex:* GC; *trifida:* GC.

Tribe PANICEAE

KEY TO THE GENERA

Fower clusters rather congested and spike-like, not widely branched; spikelets with one or more bristles at base or surrounded by bur-like involucres.

Flower clusters narrow, 5 to 15 or 25 cm long; bristles below spikelets remaining attached to axis of flower cluster after spikelets fall; annual or perennials ....(Bristle-grass) SETARIA.

Flower cluster 3 to 8 cm long; burs rather crowded along the stem, the spines numerous, spreading, falling entire; annual ....(Sand-bur) *Cenchrus pauciflorus.*

Flower clusters variously branched, sometimes with only 2 or few slender branches at top of stem; spikelets without bristles or bur-like involucres, sometimes long-silky.

Flower clusters in ours open, much-branched, with spikelets relatively few towards the ends of the branches; spikelets awnless ....PANICUM.

Flower clusters with spikelets appressed or crowded along one side of the branches for nearly their full length; southwest.

Spikelet-bearing branches about equal, 5 to 15 cm long, few to several borne at

the top of the stem and spreading like the ribs of an umbrella (digitate) (resembling Bermuda grass); spikelets awnless, appressed in 2 rows on one side of the 3-angled branch; plants annual, the stems to 100 cm high, often creeping at the base, sometimes purplish ....(Crab-grass) *Digitaria sanguinalis*.

Spikelet-bearing branches borne along the main axis, the lower longer than the upper; spikelets awned or awnless, crowded in pairs or small clusters along one side of the flowering branches, not closely appressed; branches spreading or ascending, generally less than 10 cm long.

Flower clusters 10 to 20 cm long, the lower branches to 10 cm long, sometimes again branched; spikelets rather stiff-hairy with short hairs; awned or sometimes awnless in var. *zelayensis* ....(Barnyard Grass) *Echinochloa crusgallii*.

Flower clusters 5 to 10 cm long, the branches few, 3 to 5 cm long, erect or ascending; spikelets long-silky with white to purplish hairs, the flower clusters thus resembling species of *Andropogon* ....(Cottontop) *Trichachne californica*.

SETARIA (Bristle-grass)

KEY TO THE SPECIES

Bristles below each spikelet more than 5, 4 to 8 mm long; both glumes shorter than the spikelet; stems 30 to 100 cm high; flower clusters 2 to 10 cm long, 5 to 7 mm wide.

Plants annual, the stems branching at base; spikelets about 3 mm long; southwest .... *S. lutescens*.

Plants perennial with short branching underground stems (rhizomes); spikelets about 2 to 2.5 mm long; California, low elevations ....*S. geniculata*.

Bristles below each spikelet 1 to 3 (4); second glume about as long as spikelet or only slightly shorter; southwest parks (rarely northwest).

Plants annual, the stems mostly 20 to 50 (100) cm high, branched at base.

Bristles 1 to 3 (4) below spikelets, mostly 5 to 8 (10) mm long; spikelets 2 to 2.5 mm long; flower clusters 2 to 6 (8) cm long ....*S. viridis*.

Bristles single below spikelets, mostly 2 to 6 mm long; spikelets about 2 mm long; flower clusters 5 to 15 cm long ....*S. verticillata*.

Plants perennial, the stems densely tufted, 40 to 120 cm high; flower clusters 10 to 25 cm long; bristles 8 to 15 mm long; spikelets 2 to 3 mm long ....*S. macrostachya*.

OCCURRENCE.—*Setaria geniculata:* S; *lutescens:* GC; *macrostachya:* GC; *verticillata:* GC; *viridis:* MR, G, Yl, GC.

CENCHRUS (Sand-bur)

OCCURRENCE.—*Cenchrus pauciflorus:* Yl, GC.

PANICUM

KEY TO THE SPECIES

Spikelets not hairy, tapering to a point at the tip; flower clusters large, very diffusely branched, sometimes half the length of the entire plant; stems 20 to 80 cm high, these and foliage more or less rough-hairy; leafblades 5 to 15 mm wide ....*P. virgatum* (Western Witch-grass); *P. capillare* var. *occidentale*.

Spikelets mostly hairy, oval to reverse-ovate, rounded or blunt at the tip; flower clusters reduced in size, rarely more than 10 cm long.

Stems 10 to 30 cm high, grayish-velvety; leafblades 5 to 12 mm wide; stems produced later in the season (autumnal) prostrate, branching from the lower joints and forming close mats; plants grayish-green; found in hot spring areas ....*P. thermale*.

Stems 15 to 50 (60) cm high, more or less hairy, but not velvety; leafblades to 8 (12) mm wide; plants pale or yellowish-green; not characteristic of hot springs.

Leafblades of spring (vernal) growth essentially glabrous on upper side, appressed-hairy below; later (autumnal) stems branching from lower joints, forming spreading bunches 10 to 15 cm high ....*P. scribnerianum; P. occidentale*.

Leafblades of spring growth hairy on both sides, or sometimes long-hairy on the upper side near the base only; autumnal stems branching from upper joints, or at least the branching not restricted to base only.

Upper surface of leafblades soft-hairy; spikelets more or less oval, 1.8 to 2 mm long; autumnal stems decumbent-spreading; Pacific slope .... *P. pacificum.*
Upper surface of leafblades appressed-hairy or long-hairy towards base only; spikelets reverse-ovate, 1.6 to 1.8 mm long; autumnal stems more erect; southwest .... *P. huachucae.*

OCCURRENCE.—*Panicum capillare* var. *occidentale:* Yl, Z, GC; *huachucae:* Z, GC; *occidentale:* K; *pacificum:* O, Yo, S; *scribnerianum:* Yl; *thermale:* L, Yl; *virgatum:* Yl.

DIGITARIA (*Crab-grass*)

OCCURRENCE.—*Digitaria sanguinalis:* GC.

ECHINOCHLOA (Cock-spur)

OCCURRENCE.—*Echinochloa crusgallii:* S, Yl, GC.

TRICHACHNE (Cotton-top)

OCCURRENCE.—*Trichachne californica:* GC.

Tribe AGROSTIDEAE

KEY TO THE GENERA

Spikelets strongly flattened laterally; glumes folded and compressed, the margins meeting or united towards the base, the keel (midrib forming sharp edge of fold) fringed with hairs; flower clusters dense and spike-like, ellipsoid to long-cylindric.
Glumes awned; lemmas awnless; florets falling from the glumes leaving empty glumes attached to stems .... (Timothy) PHLEUM.
Glumes awnless; lemmas awned from below middle of back; spikelets falling entire with glumes attached .... (Foxtail) ALOPECURUS.
Spikelets not strongly flattened laterally, the glumes usually more or less keeled but not strongly compressed; glumes with midrib hairy or not hairy but the keel not hairy-fringed; flower clusters various.
Spikelets breaking from flower cluster below the glumes, falling entire.
Glumes long-awned; lemma awnless or with slender awn from just below tip; flower cluster dense and spikelike; stems 15 to 50 (80) cm high ....POLYPOGON.
Glumes awnless; lemma with or without a tiny straight awn from below tip; flower clusters open, with spreading or drooping branches; stems usually taller, 60 to 120 (150) cm high .... (Wood-reed) *Cinna latifolia.*
Florets falling from glumes, leaving empty glumes attached to branches of flower cluster.
Lemma and fruit hard and firm, the body more or less cylindric, with rather stout awn from tip and a prominent thickened callus portion forming a short stalk-like base which is usually bearded or hairy.
Awn continuous from tip of lemma, divided at or above base into 3's; mostly southwest .... (Three-awn) ARISTIDA.
Awn appearing as though jointed to top of lemma, not branched; widespread, especially on dry rocky slopes in the mountains or in desert areas.
Awn usually bent once or twice, the lower section twisted, usually persistent on lemma .... (Needle-grass) STIPA.
Awn usually straight or wavy, not distinctly bent or twisted, usually soon falling from lemma .... (Rice-grass) ORYZOPSIS.
Lemma in flower and fruit rather thin, delicate or firm but not hard and indurate, awnless or with slender awn from tip or back; callus less well developed, very short and not appearing as a short stalk at base of lemma, hairy or not hairy.
Glumes mostly longer (at least one longer) than lemma, more or less keeled on back; lemma awnless or awned from the back; palea as long as or shorter than lemma.
Lemma with conspicuous tuft of hairs from short callus at base; palea about as long or ¾ as long as lemma; mostly Pacific slope and Rocky Mountain parks, few species in Southwest.

Rachilla (axis of spikelet) prolonged beyond attachment of floret as a conspicuous long-hairy bristle behind the palea; lemma awned from the back; mountain meadows ....(Reed-grass) CALAMAGROSTIS.

Rachilla not prolonged; lemma not awned; a sand-binding grass ....CALAMOVILFA.

Callus at base of lemma naked or finely hairy; rachilla not prolonged behind palea (except in 2 species), not long-hairy; lemma awnless or awned from the back; palea mostly distinctly shorter than the lemma, often entirely or nearly lacking, nearly as long in *A. semiverticillata;* widespread .... (Bent-grass) AGROSTIS.

Glumes mostly shorter than lemma, rarely equal to or longer (if longer, then distinctly awn-pointed), rounded or somewhat keeled on the back; lemma awnless or awned from the tip; palea usually about as long as lemma.

Lemma 1-, 3-, or 5 (7)-nerved, smooth or hairy at base or over back, not on nerves only.

Lemma more than 1-nerved, the nerves sometimes obscure, awnless or awn-pointed; grain at maturity remaining enclosed in its lemma and palea; seed not free inside of grain coat; ligules mostly membranous.

Glumes and lemma gradually narrowed to a sharp point, but not awn-tipped; lemma 5-nerved or sometimes obscurely 7-nerved; rather tall grass of arctic and subarctic regions ....*Arctagrostis latifolia.*

Glumes blunt or sharp-pointed; lemma 3-nerved, mostly awned or at least with a short awn-point; species common in western mountain and desert regions ....MUHLENBERGIA.

Lemma 1-nerved, never awn-pointed; grain at maturity falling free from its lemma and palea; seed becoming loose within the grain coat; ligules mostly hairy fringed; southwest ....(Dropseed) SPOROBOLUS.

Lemma 3-nerved, the nerves densely silky; palea 2-nerved, densely hairy between nerves; stems densely tufted, 20 to 60 cm high; southwest ....(Hairy Dropseed) *Blepharoneuron tricholepis.*

PHLEUM (Timothy)

KEY TO THE SPECIES

Flower clusters mostly 5 to 10 (15) cm long, mostly less than 1 cm thick; stems swollen or bulblike at base, mostly 30 to 100 cm tall; awns of glumes about ½ as long as glumes; upper leaf sheaths close to stems; widespread at lower elevations ......*P. pratense.*

Flower clusters mostly 1 to 4 cm long, 7 to 12 mm thick; stems not swollen at the base, mostly 10 to 50 cm tall; awns of glumes mostly ⅔ to ¾ as long as glumes; upper sheaths somewhat inflated; common at higher elevations ....*P. alpinum.*

OCCURRENCE.—*Phleum alpinum:* MK, O, MR, C, L, Yo, K, S, G, Yl, GT, RM, GC; *pratense:* O, MR, C, L, Yo, S, G, Yl, GT, RM, MV, B, Z, GC.

ALOPECURUS (Foxtail)

KEY TO THE SPECIES

Flowering cluster oblong to ovate, 1 to 4 cm long; glumes densely woolly; plants with slender rhizomes ....*A. alpinus.*

Flowering cluster narrowly oblong to linear, 2 to 7 cm long; glumes ciliate on the keels, not woolly all over.

Stems erect or spreading, not rooting at the joints; awns of lemmas scarcely exserted; anthers 0.5 mm long ....*A. aequalis.*

Stems tending to lie horizontally at the base and rooting at the lower joints; awns of lemmas exserted 2-3 mm.

Plants perennial; anthers 1.5 mm long ....*A. geniculatus.*

Plants annual; anthers 0.5 mm long ....*A. carolinianus.*

OCCURRENCE.—*Alopecurus aequalis* (*A. aristulatus, A. fulvus*): C, Yo, K, G, Yl, GT, RM, GC; *alpinus:* G, Yl, RM; *carolinianus:* Yl; *geniculatus:* S, GC.

POLYPOGON

KEY TO THE SPECIES

Annual with stems mostly 15 to 50 cm tall; ligule 5 to 6 mm long; glumes with awns 6 to 8 (10) mm long; flower cluster very dense and scarcely lobed .... (Rabbitfoot Grass) *P. monspeliensis.*

Perennial with stems mostly 30 to 80 cm tall; ligule 2 to 5 mm long: glumes with awns 3 to 5 mm long; flower cluster usually lobed and interrupted. (Distinguished from *Agrostis semiverticillata* by awned glumes.) .... *P. interruptus.*

OCCURRENCE.—*Polypogon interruptus:* GC; *monspeliensis:* MR, S, Yl, Z, GC.

CINNA (Wood-reed)

OCCURRENCE.—*Cinna latifolia:* O, MR, C, L, Yo, S, G, Yl.

ARISTIDA (Three-awn)

KEY TO THE SPECIES

Lower glumes more than half as long as the upper; lemmas narrowed toward summit, not twisted into beak; awns 7 to 25 mm long, about equal or the central slightly longer than the 2 laterals, somewhat divergent but not widely spreading.

Plants annual; lower glumes about 3/5 to 4/5 as long as upper; flowering cluster narrow and usually compact; awns 5 to 15 (20) mm long; stems 10 to 80 cm tall .... *A. curtisii; A. adscensionis.*

Plants perennial; glumes nearly equal; main branches of flowering cluster widely spreading; central awn 14 to 25 mm long; stems 30 to 60 cm tall .... *A. hamulosa.*

Lower glumes mostly about half (or some more than ⅔)as long as the upper; awns divergent or widely spreading; plants perennial, the stems 20 to 40 cm tall; panicle narrow, erect, with branches stiffly appressed or somewhat spreading, mostly few-flowered.

Lower glume ½ as long as upper; lemma tapering into a slender, somewhat twisted beak about half the length of the lemma; awns slender, 15 to 25 (35) mm long .... *A. arizonica; A. glauca.*

Lower glume about half as long as the upper; lemma only slightly narrowed above, not beaked; awns about equal.

First glume 8 to 10 mm long; awns about 6 to 8 cm long .... *A. longiseta.*

First glume about 7 mm long; awns about 2 to 5 cm long .... *A. wrightii; A. fendleriana.*

OCCURRENCE.—*Aristida adscensionis:* GC; *arizonica:* GC; *curtissii:* Yl; *fendleriana:* Yl, B, Z, GC; *glauca:* Z, GC; *hamulosa:* GC; *longiseta:* Yl, GC; var. *robusta:* Yl; *wrightii:* GC.

STIPA (Needle-grass)

KEY TO THE SPECIES

Lemmas conspicuously hairy, at least on upper part, with hairs 2 or more mm long, or the hairs shorter and lower part of awn plumose with hairs relatively long, mostly more than 0.5 mm long.

Lemmas densely hairy with at least the upper hairs 2 to 4 mm long and rising above the summit in a brush-like tip; awns 1.4 to 2.5 cm long, finely rough-hairy to nearly glabrous; stems often in large clumps, 30 to 60 (70) cm tall; not common in the western parks.

Flower clusters 10 to 20 or more cm long; glumes 10 to 15 (20) mm long; lemmas 6 or more mm long; leafblades 10 to 25 cm long, 2 to 5 mm wide, flat or somewhat inrolled on the margins; found in the southwest.

Lemmas 5 to 7 mm long, densely covered with long white hairs 2 to 4 mm long; awns about 2.5 cm long, mostly once- or weakly twice-bent; glumes 3- to 5-nerved; ligules 1 to 2 mm long .... *S. coronata* var. *depauperata.*

Lemmas 7 to 8 mm long, finely short-hairy below, with brush-like tip composed of hairs 2 to 3 mm long; awns 1.4 to 2 cm long, twice bent; glumes 3-nerved; ligules less than 1 mm long .... *S. scribneri.*

Flower clusters 8 to 10 cm long; glumes about 9 mm long; lemmas about 5 mm long, covered with hairs about 2 mm long and with 2 transparent teeth 1 mm long at the summit; awns about 1.5 to 2 cm long, twice bent, nearly glabrous; leaves mostly basal, the blades 5 to 12 cm long, filform with inrolled margins; ligules very short; Sierra Nevada parks .... *S. pinetorum.*

Lemmas with hairs mostly less than 2 mm long; awns 1.5 to 5 cm long, plumose on lower segments; glumes typically 3-nerved; ligule usually very short.

Awns 4 to 4.5 cm long, sharply once-bent, the lower segments with hairs 4 to 8 mm long; glumes 14 to 16 mm long; lemmas 7 to 10 mm long; sheaths glabrous or the lower finely and densely hairy, fringed with hairs on upper margins near collar; found in southwest .... *S. speciosa.*

Awns 1.5 to 5 cm long, more or less twice-bent, with hairs on lower segments not usually more than about 1 mm long; lemmas 5 to 8 mm long, uniformly short-hairy or with hairs near summit about 1.5 to 2 mm long; glumes 8 to 14 mm long; mostly Pacific slope species.

Stems 25 to 40 cm tall, in dense tufts; leafblades narrow, the margins strongly inrolled, very finely hairy on upper surface; sheaths glabrous to finely hairy; ligules 1 mm long; glumes 8 to 12 mm long; awn 1.5 to 4 cm long .... *S. occidentalis.*

Stems averaging taller, to 100 or 125 cm tall; leafblades flat or with slightly inrolled margins, 1 to 4 mm long, not characteristically finely hairy above; ligules very short.

Sheaths finely hairy; stem more or less finely hairy, especially near the joints; glumes 12 to 14 mm long; awns of lemmas 3.5 to 5 cm long .... *S. elmeri.*

Sheaths not hairy except for fringe of hairs at the throat; stems not hairy or finely hairy near the joints; glumes about 10 to 12 mm long; awns of lemmas 2.5 to 3.5 cm long .... *S. californica.*

Lemmas more or less hairy with hairs mostly less than 2 mm long, or sometimes nearly glabrous; awns very finely hairy to nearly glabrous (or terminal segment plumose).

Lemmas with hairs on upper part tending to be equal to or often longer than those below but not forming brush-like tip; first glume 3 (5)-nerved; flower clusters narrow, the branches appressed.

Sheaths with conspicuous tufts of hairs at sides of ligules and often around upper part of sheath as a collar; branches of flower cluster somewhat hairy at and below joints; awns 2 to 3 cm long.

Stems slender, 50 to 100 cm tall; leafblades 1 to 3 mm wide; ligules to 1 mm long; glumes 7 to 10 mm long; lemmas 5 to 6 mm long, with hairs 1 mm long or less; northern Rocky Mountains .... *S. viridula.*

Stems more robust, 100 to 150 cm tall; leafblades to 8 mm wide; ligules 2 to 4 mm long; glumes 8 to 12 mm long; lemmas 6 to 8 mm long, some of hairs at summit 1 to 2 mm long; ranging further south in Rocky Mountains and southwest .... *S. robusta.*

Sheaths smooth or hairy, but without tufts of hairs at the throat; stems mostly not hairy or scarcely so; ligules 0.5 to 2 mm long.

Glumes about 6 to 8 mm long; lemmas 4 to 5 mm long, with hairs on upper part to 1.8 mm long; awns about 1.5 to 2 cm long; leaves mostly basal, the blades very slender, with inrolled margins; stems in large tufts, 30 to 60 cm tall; a widespread and variable species .... *S. lettermanii.*

Glumes (6) 8 to 10 mm long; lemmas about 6 to 7 mm long, with hairs at summit not much longer than those below; leafblades 1 to 3 (4) mm wide, flat or the margins inrolled.

Sheaths and leafblades smooth or rough, mostly not distinctly hairy; ligules 1 to 2 mm long.

Stems 30 to 60 (90) cm tall; awn 2 to 3 cm long .... *S. columbiana.*

Stems 80 to 150 cm tall; leafblades averaging wider than species; awn as much as 3.5 (5) cm long; basal sheaths sometimes finely hairy .... var. *nelsonii.*

Sheaths and leafblades finely hairy, especially the lower; stems 60 to 100 cm tall; ligules about 0.5 mm long; awns 3 to 5 cm long; Rocky Mountains and Pacific slope; not very distinct from *S. columbiana* var. .... *S. williamsii.*

Lemmas rather sparsely hairy, the hairs more or less uniform in length or becoming shorter and thinner towards the summit, or the lemmas nearly glabrous.
Flower clusters more or less contracted, with appressed or ascending branches; lemmas more or less hairy on body; plants, 30 to 80 cm tall.
Glumes 3 to 5 cm long; awn plumose above .... *S. neomexicana.*
Glumes 15 to 20 mm long; lemmas mostly more than 7 mm long, thinly short-hairy or becoming naked towards tip; awns mostly (7) 10 to 15 (18) cm long; leafblades long, filiform, pale; ligules 3 to 4 (6) mm long; stems glabrous or finely hairy; widespread in Rocky Mountains and southwest.
Terminal segment of awn 8 to 15 cm long, flexuous; lemmas mostly 8 to 12 mm long; base of flower clusters usually enclosed by upper sheath ..*S. comata.*
Terminal segment of awn straight, shorter, mostly less than 7 cm long; lemmas usually longer, 12 to 15 mm long; flower clusters usually well exserted from upper sheath .... Var. *intermedia.*
Glumes 8 to 12 mm long; lemmas 7 mm or less long, finely hairy, at least on lower part; leafblades 10 to 20 cm long, 1 to 2 mm wide, flat or with inrolled margins; ligules 1 to 3 mm long; stems smooth or very finely hairy below joints.
Lemmas 6 to 7 mm long, finely hairy with appressed hairs; awns 2 to 3.5 mm long; Pacific slope .... *S. lemmonii.*
Lemmas 4 to 5 (7) mm long, finely hairy on lower half and margins; awns 4 to 6 cm long; southwest .... *S. arida.*
Flower clusters open, with spreading or drooping branches naked at base; lemmas 5 mm long, short-hairy or becoming glabrous near summit; glumes obscurely 3-nerved; awns about 2 to 3 cm long; stems 50 to 100 cm tall; leaves mostly basal; Rocky Mountains .... *S. richardsonii.*

OCCURRENCE.—*Stipa arida:* Yo (listed), GC; *californica:* C, Yo, K, S; *columbiana:* O, Yo, K, S, Yl, GT, Z; var. *nelsonii:* Yo, G, Yl, GT, RM, GC; *comata:* G, Yl, GT, RM, MV, B, Z, GC; var. *intermedia:* Yl, RM, MV, B, Z; *coronata* var. *depauperata:* GC; *elmeri:* C, Yo, K, S; *lemmonii:* K, S; *lettermannii:* C, L, Yo, K, S, Yl, GT, B, Z, GC; *neomexicana:* GC; *occidentalis:* MR, C, L, Yo, K, S, Yl; *pinetorum:* Yo, K, S; *richardsonii:* G, Yl, GT; *robusta:* RM, B; *scribneri:* GC; *speciosa:* S, GC; *viridula:* G, Yl, RM; *williamsii:* Yl.

ORYZOPSIS (Rice-grass)

Spikelets 2.5 to 4 mm long; lemma glabrous or sparingly appressed-hairy.
Flower clusters open, the branches spreading; lemma about ⅔ as long as the glumes, the awn straight.
Stems 60 to 150 cm tall; ligules about 2 mm long; leafblades flat, 6 to 10 mm wide; flower clusters 15 to 30 cm long; lemma glabrous, the awn about 4 mm long; introduced from Mediterranean and evidently has not spread far .... *O. miliacea.*
Stems 30 to 70 cm tall; ligules about 1 mm long; leafblades flat or the margins inrolled, 0.5 to 2 mm wide; flower clusters 10 to 15 cm long; lemma glabrous or appressed hairy, the awn 5 to 10 mm long; dry habitats at middle altitudes .... *O. micrantha.*
Flower clusters narrow, the branches appressed; lemma about as long as the glumes or slightly shorter, appressed-hairy, the awn bent or curved; leafblades filiform with inrolled margins.
Awn of lemma about 5 mm long, strongly bent; ligules 2 to 3 mm long; stems 15 to 30 cm tall; Rocky Mountains and northwest .... *O. exigua.*
Awn of lemma about 12 mm long, usually widely curved or arched; ligules about 1 mm long; stems 20 to 40 cm tall; Sierra Nevada .... *O. kingii.*
Spikelets 5 to 10 mm long; lemmas hairy; awn of lemma straight or weakly bent; plants 20 to 70 cm tall.
Leafblades flat, 3 to 8 mm wide; flower clusters 5 to 8 cm long, simple with short appressed branches; spikelets 6 to 8 mm long, on stalks 3 to 6 mm long; glumes 7-nerved; lemma hairy below, equalling the glumes; awn 5 to 10 mm long; Rocky Mountains .... *O. asperifolia.*

Leafblades narrow and firm, with tightly inrolled margins; flower clusters 7 to 15 cm long; spikelets on slender stalks mostly more than 8 mm long; glumes 3- to 5-nerved; lemma about half as long as glumes, densely covered with long white hairs about twice as long as lemma.

Flower clusters mostly repeatedly branched with widespreading branches; (var. *contracta* with flower clusters less open); spikelets 6 to 7 mm long; awns about 4 to 6 mm long, soon falling; widespread in Rocky Mountains and southwest .... *O. hymenoides.*

Flower clusters more contracted, the branches ascending; spikelets 8 to 10 mm long; awns about 10 to 20 mm long, weakly bent, more or less persistent (considered as possible hybrid between *O. hymenoides* and species of *Stipa.*) .... *O. bloomeri.*

OCCURRENCE.—*Oryzopsis asperifolia:* G, Yl, RM; *bloomeri:* S, B, GC; *exigua:* G, Yl; *hymenoides:* S, Yl, GT, RM, MV, B, Z, GC; var. *contracta:* B; *kingii:* Yo, K, S; *micrantha:* RM; *miliacea:* GC.

CALAMAGROSTIS (Reed-grass)

KEY TO THE SPECIES

Lemmas awned from near base (a little above); awn about as long or slightly longer than lemmas, bent and more or less exserted sideways; hairs at base of lemma short, not more than 1/3 as long as lemma, often scant.

Flower clusters open, the branches spreading, naked below; leafblades involute, filiform, forming short basal tufts; California parks .... *C. breweri.*

Flower clusters compact, spikelike, the branches appressed, flower-bearing from the base.

Leafblades 2 to 4 mm wide, flat or with inrolled margins; hairs at base of lemma about 1/3 as long as lemma.

Stems 60 to 100 cm tall; sheaths, or some of them, hairy on the collar; awn included in glumes; Rocky Mountains .... *C. rubescens.*

Stems 40 to 60 (100) cm tall; sheaths glabrous on collar; awn 5 mm long above bend, exserted about 2 mm; widespread .... *C. purpurascens.*

Plants averaging somewhat shorter, to about 80 cm, and leafblades wider than the above; hairs at base of lemma scant, scarcely 1 mm long, less than 1/3 as long as lemma; awn scarcely exserted; Rocky Mountains .... *C. koelerioides.*

Lemmas awned from about middle, sometimes somewhat above or slightly below, the awns straight, scarcely if at all exceeding the lemmas; hairs at base of lemma from half to as long as lemma (or longer).

Sheaths hairy on collar; flower clusters narrow but lax; hairs at base of lemma about half as long as lemma; not common .... *C. scribneri.*

Sheaths glabrous on collar; flower clusters contracted or open.

Flower clusters open and lax, at least some of the branches elongate and naked at base; hairs at base of lemma about as long as lemma (or longer); leafblades 4 to 8 mm wide; widespread .... *C. canadensis.*

Flower clusters contracted or spike-like, the branches short, mostly appressed and flower-bearing from the base; hairs at base of lemma ½ to ¾ as long as lemma.

Leafblades firm, rather rigid, 2 to 4 mm wide; ligules 3 to 6 mm long; spikelets 3 to 4 mm long, the glumes very rough with short stiff hairs; Pacific slope and Rocky Mountains .... *C. inexpansa.*

Leafblades soft and lax; glumes nearly glabrous or somewhat roughened.

Leafblades involute (the margins rolled under), often filiform; ligules 1 mm or less long; spikelets 3 to 3.5 mm long; Rocky Mountains .... *C. neglecta.*

Leafblades flat, 3 to 7 mm wide; spikelets 4 to 6 mm long; southwest .... *C. scopulorum.*

OCCURRENCE.—*Calamagrostis breweri:* Yo, K, S; *canadensis* (including vars. *scabra* and *macounii:* MK, MR, C, L, Yo, K, S, G, Yl, GT, RM, MV; *inexpansa:* MK, Yo, K, S, G, Yl, GT, RM, GC; *koelerioides:* G, GT; *neglecta:* G, Yl; *purpurascens:* MK, O, Yo, K, S, G, RM; *rubescens:* G, Yl; *scribneri:* Yl; *scopulorum:* B, GC.

CALAMOVILFA

OCCURRENCE.—*Calamovilfa longifolia:* Yl.

AGROSTIS (Bent-grass)

KEY TO THE SPECIES

Palea at least half as long as the lemma, 2-nerved.
 Rachilla prolonged behind palea as a minute bristle; stems tufted, 20 to 40 cm high.
  Spikelets about 3 to 4.5 mm long; palea nearly as long as lemma; rare; northwest .... *A. aequivalvis.*
  Spikelets about 2 mm long; palea about ⅔ as long as lemma; widespread in Rocky Mountains and Pacific slope .... *A. thurberiana.*
 Rachilla not prolonged behind palea.
  Dwarf alpine plants forming tufts; stems mostly not over 15 cm tall; leaves mostly basal, the blades 1 mm or less; flower clusters narrow, 1 to 3 cm long, high altitudes; Rocky Mountains and northwest .... *A. humilis.*
  More robust plants of middle altitudes; stems mostly more than 15 cm tall, often with long creeping stems (stolons) rooting at the joints; leafblades (1) 2 to 8 mm wide; flower clusters mostly 4 to 15 cm long.
   Stems 10 to 40 cm tall; flower clusters densely contracted, lobed, resembling *Polypogon* but the glumes not awn-tipped; spikelets about 2 mm long, usually falling entire; glumes scabrous over back; southwest parks ......*A. semiverticillata.*
   Stems 20 to 50 (or 150) cm tall; flower clusters open-spreading, or if contracted, the branches loose and not forming compact lobes; spikelets 2 to 2.5 mm long, the lemmas falling from the glumes; glumes smooth except for scabrous keels; widespread species.
    Flower clusters open during flowering period; leafblades mostly 5 to 8 mm wide .... *A. alba.*
    Flower clusters more or less contracted during flowering; leafblades 1 to 5 mm wide .... *A. palustris.*
Palea absent or a tiny nerveless scale.
 Plants with stems (20) 30 to 90 (120) cm tall; leafblades 1 to 10 mm wide; spikelets 2 to 4.5 mm long; middle altitudes.
  Plants with slender creeping underground stems (rhizomes); leafblades 2 to 6 mm wide; flower clusters narrow, with rather stiffly ascending branches, 10 to 15 cm long; spikelets 2.5 to 3 mm long, the lemmas awned or awnless; mostly Pacific slope .... *A. diegoensis.*
  Plants without creeping rhizomes.
   Flower clusters open, the branches branching above the middle, the lower branches naked at base; spikelets 2 to 3 mm long; leafblades 1 to 4 mm wide.
    Branches of flower cluster rather stiffly ascending; mostly northern Pacific slope.
     Lemmas awnless; bogs or wet meadows .... *A. oregonensis.*
     Lemmas awned with a straight awn; mostly coastal Alaska .... *A. alaskana.*
    Branches of flower cluster very slender, diffuse; lemmas awnless (or sometimes awned in var.); mountain meadows and open woods; widespread .... *A. scabra* and var.
   Flower clusters narrow, contracted, at least some of the lower branches bearing spikelets near base; spikelets 2.5 to 4.5 mm long; leafblades 2 to 10 mm wide; moist open ground.
    Lemmas awnless or awned from near middle with a nearly straight awn (weakly bent in var. *pacifica*); spikelets 2.5 to 4 mm long; widespread .... *A. exarata.*
    Lemmas awned from about middle with bent and twisted awn (resembling *A. exarata* var. *pacifica*); spikelets 3.5 to 4.5 mm long; not common ....*A. ampla.*
 Plants (5) 10 to 30 (40) cm high; spikelets 1.5 to 2.5 (3) mm long; leafblades narrow, not more than 3 mm wide; plants of upper altitudes.
  Flower clusters 5 to 15 cm long, open, the branches widespread; leaves mostly basal, the stems tufted.
   Spikelets 1.5 to 2.5 mm long, the lemmas awnless; widespread at medium and

high altitudes ....A. *idahoensis.*
Spikelets 2.5 to 3 mm long; high altitudes; not common in the western parks.
Lemmas awned, with usually bent exserted awn; reported from Yellowstone National Park ....*A. borealis.*
Lemmas awnless; stems with numerous short rhizomes; Sierra Nevada ....*A. lepida.*
Flower clusters 2 to 6 cm long, contracted; lemmas awnless.
Branches of flower cluster naked at base; erect annuals with leafy stems; known only from hot springs in Yellowstone National Park ....*A. rossae.*
At least some of the branches of flower cluster bearing spikelets near base; tufted perennials with mostly basal leaves; widespread in the western parks at high altitudes ....*A. variabilis.*

OCCURRENCE.—*Agrostis aequivalvis:* MR; *alaskana:* MK; *alba:* MR, Yo, K, G, Yl, GT, RM, MV, B, Z, GC; *ampla:* Yl; *borealis:* Yl; *diegoensis:* O, MR, L, Yo; *exarata:* MR, C, L, Yo, K, S, G, Yl, GT, GC; *hiemalis* (*A. scabra* as to western U. S.); *humilis:* O, MR, C, Yl, GT; *idahoensis:* MK, MR, C, L, Yo, K, S, Yl, GT, GC; *lepida:* K, S; *oregonensis:* MR, L, Yl; *palustris* (*A. alba* var.): C, Yo, K, S, G, Yl, B; *rossae* (see also *A. variabilis*): Yl; *scabra* and var. *geminata:* MK, O, MR, C, L, Yo, K, S, G, Yl, GT, RM, GC; *semiverticillata:* Z, GC; *thurberiana:* O, MR, C, L, Yo, K, S, G, Yl, RM; *variabilis* (formerly included in *A. rossae*): O, MR, C, L, Yo, K, S, G.

ARCTAGROSTIS

OCCURRENCE.—*Arctagrostis latifolia:* MK.

MUHLENBERGIA (Muhly Grass)

KEY TO THE SPECIES

Glumes nearly equal, about as long or longer than lemma; perennial plants with scaly creeping underground stems (rhizomes); ligules short, mostly less than 1.5 mm long, irregularly lacerate or short-hairy on the margin; flower clusters contracted and spike-like; lemmas hairy.
Glumes about as long as lemma (sometimes slightly more or less), pointed at the tips; lemmas awned.
Lemma with basal tuft of white hairs ⅔ to nearly as long as lemma, the awn 3 to 8 mm long; leaves glabrous, the blades flat, 2 to 6 mm wide; widespread ....*M. andina.*
Lemma and palea soft-hairy on lower half to ⅔, the awn 1 to 4 (10) mm long; leaves hairy with fine straight hairs, the blades flat or becoming inrolled at the edges, 1 to 2 (3) mm wide ....*M. mexicana, M. curtifolia.*
Glumes distinctly longer than lemma, stiffly awn-tipped; lemmas hairy on lower 1/3 to ½, awnless or rarely short awn-pointed; leaves glabrous, the blades mostly 3 to 5 (7) mm wide; widespread ....*M. setosa* var., *M. racemosa.*
Glumes mostly distinctly shorter than lemma (the upper may be nearly as long in *M. Porteri*); perennials or a few annual species, with or without rhizomes.
Upper glume 3-nerved and mostly 3-toothed; leaves mostly in a short basal tuft, the blades 1 to 2 mm wide; flower clusters narrow, with short appressed branches; lemmas more or less hairy on lower part; widespread at higher elevations.
Stems 15 to 60 (70) cm tall; leafblades 1 to 2 mm wide; ligules 2 to 4 mm long; glumes usually awn-tipped, unequal, the upper ½ to nearly as long as lemma; lemma tipped with awn (6) 8 to 15 (25) mm long; northern Rocky Mountains to the southwest, and California ....*M. montana.*
Stems 10 to 20 (30) cm tall; leafblades 1 mm or less wide; ligules 1 to 2 mm long; glumes about ½ as long as lemma, awned or awnless; lemma short awn-pointed or with awn up to about 4 mm long; middle Rocky Mountains to southwest ....*M. filiculmis.*
Upper glume 1-nerved.
Lemmas with awns mostly 5 or more mm long; mostly southwest.
Flower clusters open, nearly as broad as long, the widely spreading branches bearing rather few, long-stalked spikelets; upper glume ⅔ to nearly as long as lemma; lemma thinly hairy with fine hairs, tapering to an awn 5 to 12

mm long; a bushy perennial plant with wiry angled stems branching from nearly all the joints .... *M. porteri.*

Flower clusters narrow, the short branches more or less spreading or appressed; lemma short-hairy at base and on lower margins, the awn 10 to 20 mm long; ligules 1 to 3 (5) mm long.

Plants perennial; glumes about ⅔ as long as lemma, somewhat pointed or irregularly toothed at tip; awn of lemma usually about 10 to 20 mm long; anthers mostly 1 to 1.5 mm long; ligules 1.5 to 3 (5) mm long .... *M. monticola.*

Plants annual; glumes mostly less than half as long as lemma; awn of lemma 15 to 20 mm long; anthers mostly 0.5 to 0.8 mm long; ligules 1 to 2 (3) mm long .... *M. microsperma.*

Lemmas awnless or with awn-tips not exceeding 4 mm in length.

Flower clusters open, with slender spreading branches; spikelets 2 mm or less long; stems somewhat branching from base; ligules less than 1 mm long.

Slender annual mostly (6) 10 to 15 (25) cm tall; flower cluster 2 to 5 cm long; glumes about ½ as long as lemma; lemma scarcely more than 1 mm long, finely silky along the margins, awnless; southwest, open or wooded slopes .... *M. wolfii.*

Slender stems from slender scaly perennial rhizomes; flower clusters 5 to 15 cm long, about as wide; glumes about half to nearly as long as lemma; lemma 1.5 to 2 mm long, glabrous, awn-tipped; widespread, along streams .... *M. asperifolia.*

Flower clusters narrow, the short branches appressed.

Stems in loose tufts, slender and low, mostly 5 to 20 (60) cm tall; glumes scarcely half as long as lemma; lemma awnless or with short awn-point, glabrous or roughened with fine hairs on lower part; ligules 1 to 3 mm long; widespread in the mountains.

Annual or perennial, the stems from tufts of fibrous roots; stems glabrous or with fine stiff hairs below the joints .... *M. filiformis.*

Perennial with creeping rhizomes .... *M. repens.*

Perennial from tough matted rhizomes; stems slightly roughened between the joints with small flattish knob-like swellings. (*M. squarrosa,* a large stout form) .... *M. richardsonis.*

Stems closely tufted from a hard crown or with bulblike scaly bases, usually more than 20 cm tall, firm and wiry; mostly southwest.

Glumes awn-pointed, 1/3 to 3/4 as long as lemma; lemma 2 to 3 mm long, glabrous to finely hairy, awnless or short awn-tipped; flower cluster dense and spikelike; stems 20 to 60 cm tall; ligules 1 to 3 mm long ....*M. wrightii.*

Glumes awnless or merely tipped with short awn-point, ½ to ⅔ as long as lemma; lemma about 3 mm long, very finely hairy, usually tipped with short awn-point; flower cluster interrupted-spikelike; stems 20 to 40 cm tall; ligules less than 1 mm long .... *M. cuspidata.*

OCCURRENCE.—*Muhlenbergia andina:* Yo, S, Yl, GT, MV, Z; *asperifolia:* Yo, Yl, MV, GC; *curtifolia:* Z, GC; *cuspidata:* Yl (reported); *filiculmis:* Yl, GT, RM, GC; *filiformis:* MR, C, L, Yo, K, S, Yl, RM, GC; *mexicana:* Yl; *microsperma:* S, GC; *montana:* Yo, K, S, Yl, RM, GC; *monticola:* GC; *porteri:* GC; *racemosa:* Yl, GT, RM; *repens:* GC; *richardsonis* (*M. squarrosa*): Yo, K, S, G, Yl, GT, RM, GC; *setosa* var. *cinnoides:* G; *wolfii:* GC; *wrightii:* RM, Z, GC.

SPOROBOLUS (Dropseed)

KEY TO THE SPECIES

Sheaths glabrous except for dense tufts of white hairs at the sides or at top like a collar, the overlapping margins also sometimes fringed with hairs near the throat; upper sheath usually partly enclosing the base of flower cluster.

Flower clusters with usually more or less straight axis, contracted or open with loosely spreading ascending branches.

Flower clusters more or less open at maturity, the branches mostly naked at base; leafblades mostly 3 to 5 mm wide, flat or the margins inrolled ....*S. cryptandrus.*

Flower clusters contracted into narrow spikelike form rarely more than 1 cm thick, sometimes partially enclosed by upper sheath for most of its length, the short appressed branches spikelet-bearing to base; leafblades usually more inrolled at margins .... Var. *strictus*.

Flower clusters open, with main axis deeply arching or curved, especially towards the top, the axils of the widely spreading or recurved branches with thickened trough-like calluses which are sometimes hairy .... *S. flexuosus*.

Sheaths mostly glabrous or the lower sometimes thinly hairy on the surface, usually thinly hairy at the throat, but without tufts of white hairs forming collar; flower clusters open, the branches widely spreading at maturity and usually free from upper sheath.

Spikelets on short stalks, borne along outer ends of branchlets; stems 50 to 100 cm tall, in large clumps from a hard knotty base .... *S. airoides*.

Spikelets borne at the ends of slender stalks 10 to 25 mm long; stems 30 to 50 cm tall, tufted from a relatively soft base .... *S. texanus*.

OCCURRENCE.—*Sporobolus airoides:* V; *cryptandrus:* K, Z, GC; var. *strictus* (*S. contractus*): Z, GC; *flexuosus:* Z, GC; *texanus:* GC.

BLEPHARONEURON (Hairy Dropseed)

OCCURRENCE.—*Blepharoneuron tricholepis:* GC.

Tribe PHALARIDEAE

KEY TO THE GENERA

Glumes unequal, the first about half as long as the second; lemmas shorter than the glumes; sterile lemmas appressed-hairy with golden hairs, awned; fertile lemmas brown, glabrous, shining; flower clusters dense and spikelike, 2 to 6 cm long; perennial, the stems tufted, 30 to 60 (90) cm high, leafblades 2 to 5 mm wide; sweet smelling .... (Sweet Vernalgrass) *Anthoxanthum odoratum*.

Glumes equal; lemmas about as long as the glumes or the fertile shorter; stamen-bearing lemmas long-hairy along margins, the fertile nearly glabrous, green or yellowish; flower clusters rather loose, relatively few-flowered; perennials .... HIEROCHLOE.

ANTHOXANTHUM (Vernalgrass)

OCCURRENCE.—*Anthoxanthum odoratum:* O.

HIEROCHLOE

KEY TO THE SPECIES

Stems 10 to 40 cm high, tufted; leafblades 1 to 2 mm wide; flower clusters 3 to 4 cm long, the branches short, few-flowered; arctic species, Alaska .... *H. alpina*.

Stems 30 to 60 cm high, from creeping underground stems (rhizomes); leafblades 2 to 5 mm wide (or wider); flower clusters 4 to 12 cm long, loosely branched, the lower branches naked on lower half; moist meadows at medium elevations; Alaska and Rocky Mountain parks .... (Sweetgrass) *H. odorata*.

OCCURRENCE.—*Hierochloe alpina:* MK; *odorata:* MK, G, Yl, RM.

PHALARIS (Canary-grass)

OCCURRENCE.—*Phalaris arundinacea:* G, Yl, GT, GC; *canariensis:* Yl.

Tribe AVENEAE

KEY TO THE GENERA

Glumes 10 mm or more long.

Flower clusters loose and open, the branches bearing several to many drooping spikelets; spikelets mostly 2 (or 3)-flowered; glumes usually about equal, 20 mm or more long, longer than the florets; lemmas deeply toothed, awned from the back (or sometimes awnless), the awn stout, 3 to 4 cm long, bent and twisted, or reduced and straight .... A ENA.

Flower clusters simple, with short branches bearing one to few spikelets; spikelets 3- to several-flowered; glumes 15 mm or less long; lemmas awned, the awn conspicuously bent, the lower section twisted.
Lemma scarcely toothed at apex or with 4 short teeth, awned from the back at about the middle .... HELICTOTRICHON.
Lemma deeply toothed or lobed, the lobes narrowed into slender-pointed tips, awned from between the lobes, the twisted lower section flat and ribbon-like .... DANTHONIA.

Glumes mostly less than 8 mm long.
Spikelets 2- to 4(5)-flowered; florets alike, containing both stamens and pistil, except upper ones sometimes reduced; rachilla prolonged beyond upper floret as a slender bristle, sometimes with reduced floret attached.
Lemma awned from about middle of back or below, the tip broad, 2- to 4-toothed or irregularly toothed; rachilla conspicuously hairy, glumes longer than the florets .... DESCHAMPSIA.
Lemma awnless or awned from above the middle, narrowed to tip, with or without 2 short teeth; glumes sometimes shorter than first floret.
Spikelets mostly 2- (3 to 5)-flowered; lemma 2-toothed at apex, awned from below the tip, the awn straight or bent (or sometimes awnless); rachilla usually conspicuously hairy and the lemma usually also bearded at base .... TRISETUM.
Spikelets 2- to 4-flowered; lemma smooth or somewhat hairy on back, not bearded at base, not toothed or very short-toothed at tip, awnless or sometimes with very short awn from the tip between very short teeth; rachilla naked (not long-hairy).
Rachilla disarticulating above glumes .... KOELERIA.
Rachilla disarticulating below glumes .... SPHENOPHOLIS.
Spikelets 2-flowered, the lower awnless, perfect (with both stamens and pistil), the upper staminate and awned from the back below the tip; rachilla not prolonged above the upper floret .... HOLCUS.

AVENA (Oats)

KEY TO THE SPECIES

Lemma usually hairy below with long stiff hairs which are mostly brownish or reddish, awned from the back, the awn stout, 2.5 to 4 cm long, bent, twisted below.
Spikelets mostly 2- (or 3)-flowered; lemma 2-toothed at the tip, the teeth 4-mm or more long, bristle-like .... *A. barbata.*
Spikelets usually 3-flowered; lemma 2-toothed at the tip, the teeth not bristle-like .... *A. fatua.*
Lemma glabrous below, finely rough-hairy below the notched tip, awnless or with a slender reduced straight awn; spikelets usually 2-flowered .... *A. sativa.*

OCCURRENCE.—*Avena barbata:* Yo, S; *fatua:* MR, L, S, Yl, GC; *sativa:* G, GC.

HELICTOTRICHON

KEY TO THE SPECIES

Stems 20 to 40 cm tall; flower cluster narrow, long-exserted, 5 to 10 cm long; spikelets about 1.5 cm long, 3- to 6-flowered, the glumes shorter than the spikelet .... *H. hookeri.*
Stems 10 to 20 cm tall; flower cluster narrow, short-exserted, 2 to 5 cm long; spikelets about 1 to 1.2 cm long, mostly 2-flowered, the glumes longer than the florets .... *H. mortonianum.*

OCCURRENCE.—*Helictotrichon hookeri:* G, Yl, RM; *mortonianum:* RM.

DANTHONIA (Oatgrass)

KEY TO THE SPECIES

Lemma more or less hairy over back; leaf sheaths glabrous except hairy at the throat and sometimes on lower part near the stem joints; flower clusters few- to several-flowered.
Glumes 10 to 15 mm long; terminal segment of awn about 5 mm long .... *D. spicata.*

Glumes 20 to 22 mm long; terminal segment of awn 8 to 12 mm long ....*D. parryi.*
Lemma glabrous over back, hairy on the margins or on callus at base, or both; flower clusters one- or few-flowered.
Leaf sheaths glabrous except for long hairs in the throat (rarely the lowermost sheaths hairy;) glumes about 15 mm long; lemma appressed-hairy on the margins below and on the callus at base ....*D. intermedia.*
Sheaths conspicuously hairy.
Glumes about 15 to 20 mm long; lemmas on lower margins and on callus at base; flower clusters mostly with 2 to 5 spikelets borne singly on short spreading branches ....*D. californica* var. *americana.*
Glumes 12 to 15 mm long; lemmas glabrous except for hairs on callus at base; one-flowered, or rarely 2 (or 3)-flowered ....*D. unispicata.*

OCCURRENCE.—*Danthonia californica* var. *americana:* L, Yo, S, G, Yl; *intermedia:* O, MR, C, Yo, K, S, G, Yl, GT, RM, GC; *parryi:* G, Yl, RM; *spicata* (including *D. thermale*): O, G, Yl; *unispicata:* C, L, Yo, K, S, G, Yl.

DESCHAMPSIA (Hairgrass)

KEY TO THE SPECIES

Glumes 1-nerved, or the upper 3-nerved (sometimes obscurely so); leafblades flat or folded, mostly 2 mm or more wide; flower clusters loose or open, the branches naked below; glumes about 4 to 5 mm long; lemmas irregularly toothed at tip; anthers oblong to linear-oblong, about 1 mm long; tufted perennials.
Glumes longer than the upper floret; lemmas awned from near middle, the callus hairs at base about 1/3 to 1/2 as long as lemma; stems (15) 30 to 90 cm tall; leafblades mostly 4 to 6 (10) mm wide; flower clusters 5 to 10 cm long ....*D. atropurpurea.*
Glumes about as long as florets; lemmas usually awned from near base (sometimes from about middle or even above), the callus hairs usually less than ¼ as long as lemma; stems (20) 60 to 100 or more cm tall; leafblades (1.5) 2 to 4 mm wide; flower clusters mostly 10 to 25 cm long ....*D. caespitosa.*
Glumes 3-nerved; leafblades very narrow; lemmas more or less notched at tip, the lobes irregularly toothed; anthers oval, 0.5 mm or less long; annual or perennial.
Annual, the stems (10) 15 to 40 cm tall; flower clusters open, the slender branches naked below; glumes mostly 5 to 7 mm long, longer than the florets; lemmas awned from about middle of back, the awns about 5 to 7 (8) mm long, usually bent ....*D. danthonioides.*
Perennial, the stems very slender, mostly 25 to 90 cm tall; flower clusters long and narrow, usually 1/4 to 1/3 the length of the plant, with short slender branches closely appressed; glumes about 4 to 5 (6) mm long, equal to or slightly exceeding the upper floret; lemmas awned from a little below the middle or sometimes considerably above, the awns straight, about 2 to 4 mm long ....*D. elongata.*

OCCURRENCE.—*Deschampsia atropurpurea:* O, MR, C, G, Yl, RM; *caespitosa:* (*D. alpicola, D. curtifolia*): MK, O, MR, C, L, Yo, K, S, G, Yl, GT, RM, GC; *danthonioides:* MR, Yo, K, S; *elongata:* O, MR, C, L, Yo, K, S, G, Yl, GC.

TRISETUM (Trisetum)

KEY TO THE SPECIES

Lemmas awnless or with very tiny straight awn just below tip; stems loosely tufted, (15) 40 to 100 cm tall, sometimes with short rhizomes ....*T. wolfii.*
Lemmas awned below tip, the awns usually bent and spreading, exserted.
Flower clusters more or less open and loose, with slender lax or drooping branches naked at the base; spikelets 5 to 12 mm long, the awns mostly 5 to 10 mm long; ovary hairy at the tip ....*T. cernuum.*
Spikelets about 6 to 8 mm long (or sometimes shorter); awns usually about 6 to 8 (12) mm long; foliage conspicuously soft-hairy; Pacific slope ....*T. canescens.*
Spikelets 5 to 6 mm long; awns 5 to 8 mm long; foliage nearly glabrous to softly hairy; southern Rocky Mountains ....*T. montanum.*

Flower clusters contracted, usually dense and spikelike, 5 to 15 cm long, the short branches spikelet-bearing to base, spikelets 4 to 6 mm long; top of ovary not hairy.
Foliage hairy.
Foliage more or less finely hairy ....*T. spicatum.*
Foliage densely soft-hairy ....var. *molle.*
Foliage nearly glabrous; spikelets tending to be larger than species; high elevation form ....var. *congdoni.*

OCCURRENCE.—*Trisetum* canescens (including *T. projectum*): MR, L, Yo, K, S, G; *cernuum:* MR, G; *montanum:* RM; *spicatum* (*T. majus*): MK, O, MR, C, Yo, K, S, G, Yl, RM, GC; var. *congdoni:* Yo, K, S, GT; var. *molle:* Yo, K, S; *wolfii* (*T. brandegei*): L, Yo, K, S, G, Yl, GT, B.

KOELERIA (Junegrass)

KEY TO THE SPECIES

Plants perennial; stems very finely hairy below flower cluster ....*K. cristata.*
Plants annual; stems glabrous below flower clusters ....*K. phleoides.*

OCCURRENCE.—*Koeleria cristata:* Yo, K, S, G, Yl, GT, RM, MV, B, Z, GC; *phleoides:* L (reported).

HOLCUS (*Notholcus*)

OCCURRENCE.—*Holcus lanatus:* O, MR, Yo.

SPHENOPHOLIS

OCCURRENCE.—*Sphenopholis intermedia:* Yl; *obtusata:* Yl, GT.

ARRHENANTHERUM

OCCURRENCE.—*Arrhenantherum elatius:* Yl.

Tribe FESTUCEAE

KEY TO THE GENERA

Tall reed-like grasses 2 to 4 m high with large plume-like flower-clusters; spikelets with long silky hairs on the lemmas and rachilla; southwest ....(Common Reed) *Phragmites communis.*
Lower grasses usually less than 1.5 m tall.
Flower clusters 1-sided; escaped from cultivation.
Flower clusters simple, narrowly spike-like, 3 to 8 cm long; spikelets of two kinds, sterile and fertile, the fertile not stalked, 2- or 3-flowered with awn-tipped lemmas, closely surrounded by the short-stalked sterile spikelets; rare in the parks ....(Crested Dogtail) *Cynosurus cristatus.*
Flower clusters with few stiff branches, 5 to 20 cm long, with spikelets densely clustered towards ends of branches; spikelets all alike, not stalked, few-flowered; widespread in the parks ....(Orchard Grass) *Dactylis glomerata.*
Flower clusters various, but not 1-sided.
Lemmas 3-nerved, the nerves prominent; found mostly in Rocky Mountain and southwest parks.
Lemmas hairy on the nerves, at least below, more or less 2-lobed at the tips; found in low desert regions of the southwest ....TRIDENS.
Lemmas not hairy on the nerves, sometimes somewhat roughened or glandular on the midnerve.
Spikelets 2-flowered, the rachilla of spikelet breaking up at maturity and falling with the florets, leaving only the glumes attached; aquatic grasses with stems 10 to 40 cm long, rooting at the lower joints; Rocky Mountain parks ....(Brook Grass) *Catabrosa aquatica.*
Spikelets 3- to many-flowered; florets (in ours) falling from rachilla at maturity, sometimes leaving the palea attached; low or taller grasses of fields and waste places, especially sandy ground; mostly southwest ....(Lovegrass) ERAGROSTIS.
Lemmas 5- to many-nerved; rachilla of spikelets breaking above the glumes and between the florets.

Florets naked at the base; (lemmas usually cobwebby at base in *Poa*); leaf sheaths open or closed.

Nerves of lemma parallel, not converging at summit or but slightly so.

Flower clusters simple, with short-stalked spikelets borne singly along the stem; lemmas awned from the tip; stems 100 to 150 cm high; in wet meadows or along streams in the northwest ....(Semaphoregrass) *Pleuropogon refractus.*

Flower clusters branched; lemmas awnless; low to tall grasses.

Lemmas mostly strongly 7-nerved; glumes mostly 1-nerved (the second 3-nerved in *G. pauciflora*); sheaths closed or partly closed; widespread in the parks, in woods or along fresh water streams or marshes .... (Mannagrass) GLYCERIA.

Lemmas mostly faintly 5-nerved; at least the second glume 3-nerved; sheaths open (the margins free); not common in the parks, usually in alkali soil ....(Alkali-grass) PUCCINELLIA.

Nerves of lemma tending to converge toward tip.

Erect stems mostly less than 30 cm high, rather wiry-rigid with stiff pointed leafblades, arising from underground stems (rhizomes), often close together and somewhat matted; spikelets mostly 7- to 15-flowered; lemmas tightly overlapping, faintly 9- to 11-nerved, not awned; spikelets closely grouped into elongate head-like clusters; the male (staminate) and female (pistillate) borne on separate plants; not common in our area .... (Saltgrass) DISTICHLIS.

Stems low or tall, loosely or densely clustered, with or without creeping rhizomes, often stout or tough but not wiry; spikelets mostly fewer-flowered (3 to 6 or 8), or if more, then the lemmas awned (except *Bromus catharticus*); plants mostly with perfect spikelets, the florets containing both pistil and stamens (except in *Hesperochloa* and sometimes in *Poa fendleriana*).

Lemmas 5-nerved, awnless or awned from the tip or near the tip; leaf sheaths open, the margins free.

Leafblades flat or plane at the tip, not boat-shaped; lemmas rounded on the backs, awned or awnless, not papery at the tips, not webbed at the base.

Male (staminate) and female (pistillate) flowers borne in spikelets on separate plants; lemmas awnless, pointed; Rocky Mountains ....(*Festuca kingii*) *Hesperochloa kingii.*

Spikelets perfect, bearing both staminate and pistillate flowers; lemmas mostly awned from the tips or at least awn-pointed, sometimes awnless; widespread in the parks but not as common as *Poa* ....(Fescue) FESTUCA.

Leafblades boat-shaped at tip; lemmas mostly somewhat keeled on the back (rounded in some species), awnless, somewhat membranous, often papery at the tips and upper margins, most species commonly with a web of cottony hairs at the very base and often hairy on the nerves at least below; widespread ......(Bluegrass) POA.

Lemmas 5- to 9-nerved, awnless or awned from between two small teeth at the tip; leaf sheath a closed cylinder surrounding the stem.

First glume 1- to 5-nerved, the second 3- to 7-nerved; spikelets mostly more than 6-flowered, the lemmas awned (except 1 species); glumes pointed at the tips, not papery-margined .... (Brome-grass) BROMUS.

Glumes 3-to 5-nerved; spikelets mostly 2- to 6-flowered (rarely 1-flowered), often more or less purplish; lemmas awnless and glumes broad and papery or lemmas awned and glumes narrower and papery on margins only ....(Melic-grass) MELICA.

Florets long-hairy from the base; lemmas strongly 7-nerved, awned from just below the notch of the 2-toothed tip; leaf sheaths open; stems 50 to 100 cm high; flower clusters simple, with few short branches bearing 1 or 2 spikelets; Rocky Mountain parks ....(False Melic) *Schizachne purpurascens.*

PHRAGMITES (Reed)

OCCURRENCE.—*Phragmites communis:* Yl, Z, GC.

CYNOSURUS (Dogtail)

OCCURRENCE.—*Cynosurus cristatus:* MR.

DACTYLIS (Orchard Grass)

OCCURRENCE.—*Dactylis glomerata:* O, MR, C (reported), Yo, Yl, GT, MV, Z, GC.

TRIDENS (Triodia)

KEY TO THE SPECIES

Stems 30 to 50 cm high; leafblades flat to somewhat inrolled along the margins, 1 to 3 mm wide; flower clusters narrow, to 12 cm long; spikelets scarcely flattened, about 1 cm long; lemmas densely hairy on lower half of the nerves, the tips blunt-pointed or with very short notch, not awned .... *T. muticus.*

Stems 3 to 30 cm high; leafblades flat or folded or the margins inrolled, 1 to 1.5 mm wide; flower clusters short, more or less head-like, not generally exceeding 2 (4) cm in length; spikelets flattened; lemmas long-hairy over the back on the lower part, toothed at the tip, awned with an awn 1 to 2 mm long.

Stems 10 to 30 cm high, densely tufted; spikelets 3 to 10, short-stalked, 1 to 1.5 cm long; lemmas with very short teeth at the tip, hairy at the base .... *T. pilosus.*

Stems less than 15 cm high, each producing a cluster of leaves at the single upper joint, eventually bending over and rooting at the joint to produce a new plant; spikelets 1 to 5, scarcely stalked, 0.8 to 1 cm long; lemmas long-hairy over lower half, deeply toothed at the tip .... (Fluffgrass) *T. pulchellus.*

OCCURRENCE.—*Tridens muticus:* GC; *pilosus:* MV, GC; *pulchellus:* Z, GC.

CATABROSA (Brook-grass)

OCCURRENCE.—*Catabrosa aquatica:* G, Yl.

ERAGROSTIS (Lovegrass)

KEY TO THE SPECIES

Spikelets mostly 4- to 6-flowered, lance-shaped to oblong-ovate, 4 to 7 mm long.

Stems 60 to 120 cm high; perennial; sandy ground in the southwest .... *E. trichodes.*

Stems 30 cm high or less; annual .... *E. mexicana.*

Spikelets mostly more than 6-flowered, oblong to linear, 4 to 15 mm long; leaf sheaths hairy on the collar at the throat; annuals, with stems 10 to 50 (100) cm high.

Plants with a strong disagreeable sweetish odor due to glandular secretions from evident glandular depressions on the margins of the leaves, midnerves of the sheaths, branches of flower cluster, and on midnerves of the lemmas; spikelets oblong, compressed, 2.5 to 3 mm wide, 5 to 15 mm long, 10- to 40-flowered; stems 10 to 50 cm high; found in disturbed ground .... (Stink-grass) *E. cilianensis.*

Plants without strong odor, not glandular; spikelets linear, 1 or 2 mm wide, 4 to 9 mm long, 6- to 15-flowered; waste ground.

Stems 60 to 100 cm high; spikelets 1 mm wide; California .... *E. orcuttiana.*

Stems 30 to 50 cm high, tufted; spikelets about 2 mm wide; southwest .... *E. diffusa.*

OCCURRENCE.—*Eragrostis cilianensis:* Yo; *diffusa:* GC; *mexicana:* GC; *orcuttiana:* S; *trichodes:* GC.

PLEUROPOGON (Semaphore Grass)

OCCURRENCE.—*Pleuropogon refractus:* O, MR, C.

GLYCERIA (Mannagrass)

KEY TO THE SPECIES

First and second glumes 1-nerved; lemmas strongly 7-nerved; margins of leaf sheaths united into a cylinder surrounding the stem (or sometimes overlapping) for most of their length.

Flower clusters 20 to 40 cm long; first glume 1.5 (2) mm long, the second 2 to 3 mm long.
Stems 50 to 100 cm high; leafblades 2 to 4 (8) mm wide; leaf sheaths overlapping; ligules 5 to 7 mm long; flower clusters narrow; spikelets linear, 10 to 15 mm long, 6- to 12-flowered, closely appressed to the branches; widespread .... *G. borealis.*
Stems 100 to 150 cm high; leafblades 6 to 12 mm wide; ligules about 3 mm (or more) long: flower clusters widely open; spikelets oblong, 5 to 6 mm long, 4- to 7-flowered, loose; Rocky Mountains .... *G. grandis.*
Flower clusters open, 10 to 30 cm long; first glume 0.5 to 1 mm long, the second 1 to 1.5 mm long.
Stems 30 to 100 cm high; leafblades 2 to 4 (8) mm wide, rather firm; ligules 2 to 3 mm long; spikelets ovate to oblong, 3 to 4 mm long, 5- to 7-flowered; first glume about 0.5 mm long; mostly Rocky Mountains and southwest .... (*G. nervata*) *G. striata.*
Stems 100 to 200 cm high; leafblades 6 to 12 mm wide, lax; ligules 3 to 4 mm long; spikelets oblong, 4 to 6 mm long, 6- to 8-flowered; first glume about 1 mm long; mostly Pacific slope and Rocky Mountain parks .... *G. elata.*
Second glume 3-nerved; lemmas 5-nerved; sheath margins free.
Stems 50 to 120 cm high; leafblades 5 (8) to 12 (15) mm wide; ligules 5 to 6 mm long; flower clusters 10 to 20 cm long, with spreading or ascending flexuous branches; Pacific slope and Rocky Mountains .... *G. pauciflora.*
Stems 10 to 40 cm high; leafblades 4 to 9 mm wide; flower clusters 3 to 8 cm long, narrow with ascending branches; Pacific slope .... *G. erecta.*

OCCURRENCE.—*Glyceria borealis:* MR, Yo, S, G, Yl, GT, RM, GC; *elata:* MR, C, L, Yo, K, S, G, Yl, GT, RM; *erecta:* C, Yo, S; *grandis:* Yl, RM, *pauciflora:* O, MR, C, Yo, K, S, G, Yl, GT, RM; *striata* (*G. nervata*): C, G, Yl, GT, Z, GC.

PUCCINELLIA (Alkali-grass)

KEY TO THE SPECIES

Stems slender, 20 to 60 (70) cm high; flower clusters loose and open, with spreading or reflexed branches and the longer naked for at least half their length; spikelet 4 to 7 mm long, (3) 4- to 6-flowered; lemmas glabrous or sometimes finely hairy at base; anthers less than 1 mm long.
Flower clusters with the branches reflexed; spikelets about 4 to 5 mm long; lemmas 1.5 to 2 mm long; first glume about 0.5 to 1 mm long, the second 1 or 1.5 to 2 mm long.
Stems 40 to 70 cm high, very slender; leafblades short, narrowly filiform; anthers scarcely 0.5 mm long; Alaska .... *P. hauptiana.*
Stems 20 to 40 (60) cm high; leafblades 2 to 4 mm wide; anthers about 0.8 mm long; not common in the western parks; northwest .... *P. distans.*
Flower clusters with the branches ascending at first, finally spreading; lemmas 2 to 3 mm long; first glume about 1.5 mm long, the second about 2 mm long; stems 30 to 60 (100) cm high; leafblades 1 to 3 mm wide; anthers about 0.7 mm long; Rocky Mountains and southwest .... (*P. nuttalliana*) *P. airoides.*
Stems stout, 50 to 90 cm high; leafblades firm, 2 to 4 mm wide; flower clusters at first contracted, the branches finally spreading; spikelets 8 to 15 mm long, 5- to 15-flowered; lemmas 3 to 4 mm long, sparsely hairy at base; anthers 1.3 to 1.5 mm long; sea coast in the northwest .... (*P. nutkaensis* of Amer. authors) *P. grandis.*

OCCURRENCE.—*Puccinellia airoides:* G, Yl, MV, Z; *distans:* O, MR, Yl; *grandis* (*P. nutkaensis* of Amer. authors): O; *hauptiana:* MK.

DISTICHLIS (Saltgrass)

KEY TO THE SPECIES

Flower clusters with closely condensed spikelets; spikelets mostly 5- to 9-flowered; paleas of pistillate (female) florets with narrow untoothed wings along the keeled sides; coastal in northwest .... *D. spicata.*
Flower clusters with spikelets more loosely arranged; spikelets of male (staminate)

plants 8- to 15-flowered, those of female (pistillate) plants 7- to 9-flowered; paleas of pistillate florets with broader irregularly toothed wings; found in alkaline soil in the interior .... *D. stricta.*

OCCURRENCE.—*Distichlis spicata:* O; *stricta:* G, Yl, MV,, Z, GC.

HESPEROCHLOA

OCCURRENCE.—*Hesperochloa kingii* (*Festuca kingii, F. confinis*): S, G, Yl, GT, MV.

FESTUCA (Fescue)

KEY TO THE SPECIES

Lemmas awnless or with short awns not over half the length of the body of the lemma; plants perennial.

Leafblades flat, 4 to 8 mm wide; spikelets 6 to 12 mm long, 6- to 8-flowered; lemmas 5 to 7 mm long, glabrous, not awned or rarely very short-awned; stems 50 to 120 cm high, loosely tufted, sometimes with short creeping rootstocks; often cultivated for meadow or pasture .... *F. elatior.*

Leafblades narrow, mostly less than 4 mm wide, commonly folded or the margins inrolled; spikelets 3- to 7-flowered; stems 30 to 90 (100) cm high.

Stems loosely tufted; leafblades glabrous, soft.

Lemmas 6 to 8 mm long, glabrous, awnless; flower clusters more or less open, the lower branches mostly in pairs, spreading or ascending; plants mostly green; northwest .... *F. viridula.*

Lemmas 5 to 7 mm long, glabrous or roughened towards tip, awned, the awn about half as long as lemma; flower clusters contracted after flowering, the branches solitary or the lower paired; spikelets often purplish; lowermost leaf sheaths usually purplish or brownish-red, becoming loosely fibrous; northwest and Rocky Mountains.

Lemmas glabrous .... *F. sororia; F. rubra.*

Lemmas hairy .... var. *lanuginosa.*

Stems very densely tufted; leafblades firm, more or less roughish.

Glumes rather broadly lance-shaped to ovate, thinnish and more or less membranous; flower clusters with spreading or ascending branches naked below and becoming appressed after flowering; the following 3 species similar; not common in the western parks.

Ligules 2 to 4 (6) mm long; lower branches of flower clusters usually solitary; lemmas faintly nerved, awnless; stems 60 to 90 cm high; Rocky Mountains .... *F. thurberi.*

Ligules short; lower branches of flower clusters usually in 2's or 3's; lemmas strongly nerved, awnless or sometimes very short-awned; stems 30 to 90 cm high; blades of basal leaves breaking away from sheaths which persist in the basal tuft.

Lemmas about 7 mm long; anthers 4 mm long; northern species .... *F. altaica.*

Lemmas 7 to 10 mm long; anthers 3 mm long; Rocky Mountains .... *F. scabrella.*

Glumes more narrowly lance-shaped, rather firm in texture; flower clusters narrow and spikelike, with short branches appressed or somewhat spreading at flowering time; leafblades very slender; widespread species.

Stems mostly 30 to 100 cm high; basal leaves rough, usually more than half the length of the stems; lemmas about 7 mm long.

Awns of lemmas usually 2 to 4 mm long; ligules very small, not more than 1 mm long; Pacific slope and Rocky Mountains .... *F. idahoensis.*

Awns of lemmas less than 2 mm long, sometimes lacking; ligules evident, up to 2 mm long; southern Rocky Mountains and southwest .... *F. arizonica.*

Stems mostly (5) 20 to 40 cm high; basal leaves less rough to nearly smooth, usually less than half the length of the stems; lemmas 2 to 5 mm long, short-awned.

Stems 20 to 40 cm high; lemmas 4 to 5 mm long; anthers 2.5 to 3 mm long; lower elevations, mostly Rocky Mountains and southwest. (*F. minutiflora,* a form with small florets) .... *F. ovina.*

Stems 5 to 20 cm high; lemmas 2 to 3 mm long; anthers 0.5 to 1 mm long; alpine, Pacific slope and Rocky Mountains ....var. *brachyphylla*.

Lemmas distinctly awned, the awns about as long or longer than body of lemma; glumes very narrow.

Flower clusters narrow, with short appressed branches; leafblades narrow; plants annual.

Stems mostly 15 to 30 cm high; spikelets 6 to 8 mm long, densely 5- to 15-flowered; lemmas firm, glabrous or roughish, the margins not membranous; awns nearly as long or sometimes longer than lemmas, 3 to 5 (7) mm long; southwest .... *F. octoflora*.

Stems 20 to 60 cm high; spikelets 4- or 5-flowered; lemmas with narrow membranous margins; awns about or nearly twice as long as lemmas.

First glume about 4 mm long, about ⅔ as long as second; lemmas roughish on back towards tip, not hairy; awn 10 to 13 mm long; widespread but not common in western parks ....*F. dertonensis*.

First glume 1.5 to 2 mm long, scarcely half as long as second; lemmas with hairy fringe on upper margins; awn 8 to 10 mm long; Pacific slope .... *F. megalura*.

Flower clusters more or less open with spreading, drooping or reflexed branches.

Stems 40 to 100 cm high; flower clusters 7 to 20 or 40 cm long, loose, open, often drooping, the lowermost branches usually in 2's or 3's or sometimes solitary; plants perennial.

Leaves not mostly basal, the blades flat, thin, lax, at least those of the stem 2 mm or more wide; lemmas 6 to 8 mm long, with awns 5 to 20 mm long.

Flower clusters 10 to 20 cm long; spikelets with florets stalked and appearing widely separated on a jointed axis; awns of lemmas 10 to 15 mm long; rare, northwest ....*F. subuliflora*.

Flower clusters 15 to 40 cm long; florets not stalked; awns of lemmas 5 to 20 mm long, somewhat flexuous; Pacific slope ....*F. subulata*.

Leaves mostly basal, the blades narrow, with inrolled margins, 5 to 20 cm long; lemmas 5 to 6 mm long, with awns from half to as long or somewhat longer than lemmas; Pacific slope and northern Rocky Mountains ....*F. occidentalis*.

Stems 20 to 40 cm high; flower clusters 5 to 12 cm long, the branches solitary, at least the lower reflexed at maturity; plants annual; infrequent in the western parks.

Leafblades 3 to 5 cm long; spikelets 3- to 6-flowered; lemmas 6 to 7 mm long; awns 10 to 15 mm long ....*F. pacifica*.

Leafblades 2 to 10 cm long; spikelets 1- to 3-flowered; lemmas 5 to 6 mm long; awns usually 5 to 8 mm long.

Lemmas glabrous or roughish ....*F. reflexa*

Lemmas hairy ....*F. microstachys*.

OCCURRENCE.—*Festuca altaica:* MK; *arizonica:* RM, GC; *dertonensis:* O; *elatior:* MR, Yl, RM, MV, B; *idahoensis:* O, C, G, Yl, GT, RM; *megalura:* O, Yo; *microstachys:* MR; *occidentalis:* O, MR, C, G, Yl; *octoflora:* Yl, GC; *ovina* (*F. minutiflora*): MK, S, G, Yl, RM, GC; var. *brachyphylla* (*F. brachyphylla*): O, MR, Yo, K, S, G, Yl, GT, RM, GC; *pacifica:* Z; *reflexa:* K, S; *rubra:* O, MR, Yo, K, S, G, Yl; var. *lanuginosa:* MK; *scabrella:* G, Yl; *sororia:* GC; *subulata:* O, MR, S, G, Yl; *subuliflora:* O; *thurberi:* Yl, RM; *viridula:* MR, C.

POA (Bluegrass)

KEY TO THE SPECIES

Lemmas hairy on nerves, at least on lower part of midnerve and lateral nerves.

Lemmas webbed at base with a tuft of long crinkly hairs, or the web sometimes scant.

Spikelets rather closely flowered, the lemmas mostly 2 to 3 (4) mm long.

Stems 30 to 100 (or more) cm high; lower branches of flower clusters mostly in 3's to 5's; lemmas mostly copiously webbed at base; widespread species.

Stems arising from creeping underground stems (rhizomes); leafblades 2 to 4 mm wide; ligules (0.5) 1 to 2 mm long ....(Kentucky Bluegrass) *P. pratensis*.

Stems loosely tufted, often purplish at base, without creeping rhizomes; leafblades 1 to 2 mm wide; ligules on stem leaves 3 to 5 mm long ....*P. palustris*.

Stems 15 to 50 (70) cm high; lower branches of flower clusters solitary or in 2's or 3's; Rocky Mountains and southwest.

Branches of flower clusters usually reflexed, bearing spikelets mostly near tips of branchlets; leafblades 1 to 4 mm wide; ligules 1 to 2 mm long; base of lemma distinctly webbed .... *P. reflexa.*

Branches of flower clusters appressed or ascending, some spikelet-bearing to near base; web at base of lemma often scanty or wanting.

Stems strongly flattened, arising singly or few together from creeping underground stems (rhizomes); leafblades 1 to 4 mm wide; lemmas with scant web at base or not webbed .... *P. compressa.*

Stems not strongly flattened, more or less tufted, without creeping rhizomes.

Plants perennial, densely tufted; leafblades 1 to 2 mm wide; ligules usually less than 1 mm long; web at base of lemma sometimes scant or obscure .... *P. interior.*

Plants annual; leafblades 1 to 3 (5) mm wide; ligules usually 1 to 2 mm long; lemmas webbed at base .... *P. bigelovii.*

Spikelets more loosely flowered, the lemmas mostly 4 to 5 (6) mm long, tending to be purplish; perennials; Pacific slope and Rocky Mountains.

Lemmas only sparsely hairy on lower part of nerves, distinctly webbed at base; glumes and lemmas gradually narrowed to a long point; flower clusters nodding, the loose branches spikelet-bearing only towards the tips; leafblades 2 to 4 mm wide; ligules 3 to 5 mm long.

Erect stems to 100 or 120 cm high, from creeping underground stems (rhizomes); flower clusters 10 to 15 cm long, the lower branches in 3's or 4's; moist woods in the northwest, not common .... *P. laxiflora.*

Stems 20 to 50 cm high, without creeping rhizomes; flower clusters 5 to 12 cm long, the lower branches mostly in pairs; boggy areas at high altitudes; widespread, Pacific slope and Rocky Mountains .... *P. leptocoma.*

Lemmas densely hairy on lower half of midnerve and lateral nerves, the web at base sometimes scanty or wanting; glumes and lemmas generally broader near tip, more abruptly pointed; flower clusters erect or somewhat lax, but not nodding, the branches spreading or ascending; leafblades 1 to 3 mm wide.

Stems mostly 35 to 100 (150) cm high; not common in the western parks.

Flower clusters 10 to 30 cm long, with widely spreading branches as much as 8 or 10 cm long; branches naked on the lower half to ⅔; ligules 2 to 3 (8) mm long; plants without creeping rhizomes; medium elevations.

Leafblades 3 to 6 mm wide; lower branches of flower clusters in 3's to 5's; lemmas conspicuously webbed at base; mostly southern Rocky Mountains .... *P. occidentalis.*

Leafblades 2 to 3 mm wide; lower branches of flower clusters in 2's or 3's; web at base of lemma scanty if present; northwest ...... *P. macroclada.*

Flower clusters less than 10 cm long, the branches shorter, to 2 or 3 cm long, ascending; ligules evident but less than 2 mm long; web at base of lemma conspicuous; plants with slender creeping underground stems (rhizomes); Alaska .... *P. lanata.*

Stems mostly 10 to 30 cm high; Pacific slope and Rocky Mountains; rather widespread at high elevations.

Lemmas not hairy on internerves between midnerve and lateral nerves, usually webbed at base; leafblades mostly 1 to 2 mm wide; stems tufted, without creeping rhizomes .... *E. paucispicula.*

Lemmas hairy on internerves as well as on the midnerve and lateral nerves, often not webbed at base; stems loosely tufted.

Stems 10 to 30 cm high; leafblades 2 to 3 mm wide; ligules pointed, to 4 mm long; flower clusters 5 to 10 cm long, open, the branches usually spreading; plants with or without creeping underground stems (rhizomes) .... *P. arctica.*

Stems 10 to 20 cm high; leafblades about 1 mm wide; ligules about 2 mm long; flower clusters 1 to 4 cm long, narrow and condensed; without creeping rhizomes .... *P. pattersonii.*

Lemmas not webbed at base or sometimes very sparsely.

Flower clusters rather compact or condensed, the branches short, usually appressed and at least some spikelet-bearing to near base; perennials.

Stems (15) 20 to 60 (70) cm high; leafblades 1 to 4 mm long; spikelets greenish, pale, or sometimes the lemmas somewhat bronzed on the margins; medium elevations; mostly Rocky Mountains and southwest.

Stems from creeping underground stems (rhizomes); flower clusters 2 to 10 cm long.

Stems strongly flattened; ligules less than 2 mm long; lemmas hairy only on midnerve and lateral nerves, sometimes with a scant web at base .... *P. compressa*

Stems not flattened; ligules 2 to 4 mm long; lemmas hairy on internerves as well as midnerve and lateral nerves .... *P. arida*.

Stems tufted, without creeping rhizomes; flower clusters 2 to 7 cm long.

Ligules less than 1 mm long .... *P. fendleriana*.

Ligules prominent, up to 5 (or 7) mm long .... *P. longiligula*.

Stems 6 to 30 cm high; leafblades 1 to 5 mm wide; spikelets usually purplish; high elevations.

Stems 10 to 30 (40) cm high; flower clusters 1 to 8 cm long, more or less ovate, about as broad as long during the flowering period when the lower branches are spreading or reflexed; leafblades 2 to 5 mm wide; lemmas hairy on internerves as well as midnerve and lateral nerves; northwest and Rocky Mountains .... *P. alpina*.

Stems 6 to 20 cm high; flower clusters 1 to 4 cm long, much longer than broad, the branches appressed or ascending; leafblades about 1 to 1.5 mm wide, usually folded; Sierra Nevada and Rocky Mountains.

Stems rather lax, loosely tufted; ligule very inconspicuous; lemmas hairy on internerves, sometimes sparsely webbed at base .... *P. pattersonii*.

Stems stiff, densely tufted; ligule about 1.5 mm long; lemmas sometimes finely hairy on internerves, not webbed at base .... *P. rupicola*.

Flower clusters less condensed, open or contracted, at least the lower branches naked at the base; perennials (except *P. annua*).

Flower clusters narrow, the branches ascending but rather loose and naked at base; mostly Rocky Mountains (also Alaska).

Stems tufted, 10 to 50 (70) cm high, without creeping rhizomes; leafblades 1 to 2 mm wide; branches of flower clusters mostly in 2's; medium elevations and extending above timberline.

Ligules usually less than 1 mm long; lemmas mostly webbed at base, the web sometimes obscure, not hairy on internerve .... *P. interior*.

Ligules usually about 2 mm long; lemmas rarely scantily webbed, often sparsely hairy on internerves as well as on midnerve and lateral nerves .... *P. glauca*.

Stems loosely tufted, 60 to 100 cm high, from creeping underground stems (rhizomes); leafblades 2 to 3 mm wide; at least the lower branches of flower cluster in 3's; lemmas softly hairy on midnerve and lateral nerves and more or less so on internerves below; medium elevations ......*P. glaucifolia*.

Flower clusters with branches widely spreading, reflexed or drooping.

Stems 5 to 30 cm high; branches of flower clusters solitary or in 2's; Pacific slope and Rocky Mountains.

Stems tufted, forming mats; foliage and flower clusters bright green; leafblades 1 to 3 mm wide; lemmas hairy on the prominent internerves as well as the midnerve and lateral nerves (long basal hairs sometimes resemble a web); annual, medium elevations .... *P. annua*.

Stems loosely tufted; flower clusters purplish; alpine perennials.

Lemmas hairy on internerves as well as on midnerve and lateral nerves, often webbed at base; plants with or without creeping rhizomes; leafblades 2 to 3 mm wide; ligules pointed, to 4 mm long .... *P. arctica*.

Lemmas hairy only on midnerve and lateral nerves, not on internerves; plants without creeping rhizomes; leafblades 1 to 2 mm wide; ligules to about 2 mm long.

Lemmas usually more or less webbed at base; northwest ....*P. paucispicula.*

Lemmas not webbed at base; Alaska ....*P. brachyanthera.*

Stems 30 to 80 cm high; lower branches of flower clusters in 2's or 3's, naked on the lower half or ⅔.

Stems from creeping underground rhizomes; ligules 1 to 2 mm long; lemmas strongly nerved, hairy or glabrous on lower part of nerves; widespread species ....*P. nervosa.*

Creeping rhizomes not present; ligules 2 to 3 (or 5) mm long.

Stems 30 to 60 cm high; leafblades 1 to 2 mm wide; ligules as much as 5 mm long; flower clusters 5 to 15 cm long.

Flower clusters nodding, the lower branches in 2's and 3's; lemmas hairy only on nerves below; northwest ....*P. stenantha.*

Flower clusters more or less erect, the lower branches in 2's to 6's; lemmas hairy over back at base, but more densely so on nerves; California and Rocky Mountains ....*P. gracillima.*

Stems 50 to 80 cm high; leafblades 2 to 3 mm wide; ligules 2 to 3 mm long; flower clusters erect with spreading branches; lemmas sometimes with scant web at base; rare, in the northwest ....*P. macroclada.*

Lemmas glabrous or merely roughish on the back, or if hairy, the hairs more or less evenly distributed over the lower part, not restricted mostly to the nerves.

Lemmas with a web-like tuft of long hairs at the base, mostly rather slender and gradually narrowed to a long point; branches of flower cluster rather few and far apart, at least the longer naked below.

Stems 15 to 60 cm high, solitary or few in a small tuft; leafblades 2 to 4 (5) mm wide; fairly common.

Flower clusters about half the length of the stem, the branches widely and stiffly spreading at maturity; spikelets closely appressed to the branches; lemmas with intermediate nerves not evident, scantily webbed at base; plants annual; medium elevations, California parks ....*P. bolanderi.*

Flower clusters usually less than half the length of the stem, 5 to 10 cm high, nodding, the branches lax, spreading or ascending; spikelets not closely appressed to the branches; lemmas with intermediate nerves distinct, mostly somewhat hairy on midnerve and lateral nerves, webbed at base; plants perennial; medium to high elevations, Pacific slope and Rocky Mountains ....*P. leptocoma.*

Stems 40 to 100 (120) cm high; leafblades 1 to 4 mm wide; flower clusters 10 to 18 cm long; rare in the northwest.

Ligules very short; flower clusters strongly drooping, the branches ascending or appressed, solitary or the lower in pairs; lemmas glabrous on back except for webbed base; stems in small tufts, without creeping rhizomes ....*P. marcida.*

Ligules 3 to 5 mm long; flower clusters lax or nodding, the branches spreading, the lower in 3's or 4's; lemmas usually sparsely hairy on lower part of nerves; stems from creeping underground stems (rhizomes) ....*P. laxiflora.*

Lemmas not webbed at base, slender or broad at the tips; flower clusters more congested (except *P. nervosa*).

Lemmas essentially glabrous on the back; flower clusters 1 to 5 cm long; contracted, with short appressed branches, or the branches somewhat spreading during the flowering period.

Leafblades all very slender, filiform or scarcely more than 1 mm wide, mostly in basal tufts; ligules mostly 1 to 2 mm long or less.

Stems 3 to 30 cm high; lemmas not exceeding 4 mm long; flower clusters often purplish; alpine meadows and summits.

Stems 3 to 10 cm high, scarcely exceeding the leaves; leafblades somewhat lax; flower clusters 1 to 3 cm long; rocky alpine summits ....*P. lettermanii.*

Stems 5 to 30 cm high; leafblades rather firm; flower clusters 2 to 5 cm long; alpine meadows ....*P. leibergii.*

Stems 10 to 60 cm high, densely tufted; lemmas 4 to 6 (8) mm long; flower clusters usually pale, silvery or tawny or sometimes purplish-tinged; in the mountains at medium and high elevations.

Stems 10 to 20 cm high, the lower sheaths loose and papery; flower clusters 1 to 5 cm long; spikelets 6 to 8 mm long; rocky alpine summits .... P. *pringlei.*

Stems 20 to 60 cm high; flower clusters 2.5 to 8 cm long; spikelets 7 to 9 mm long; dry rocky slopes at medium and high elevations .... *P. cusickii.*

Stem leaves with blades 2 to 3 mm wide; those of basal shoots slender, filiform, only 1 mm wide; stems 15 to 40 cm high, in loose to dense tufts; ligules about 3 mm long; flower clusters about 2 to 6 cm long, usually purplish; mountain meadows and forest openings .... *P. epilis.*

Lemmas nearly glabrous to finely crisp-hairy or roughish on the back especially near the base; flower clusters (2) 5 to 12 cm long.

Flower clusters more or less common, the branches spreading or ascending; stems 30 to 60 cm high; Pacific slope and Rocky Mountains.

Lemmas glabrous or hairy on the nerves; stems from creeping underground rhizomes; leafblades flat or folded, 2 to 4 mm wide; ligules 1 to 2 mm long; middle elevations .... *P. nervosa.*

Lemmas hairy over back at base, more densely so on nerves; stems without rhizomes; leafblades filiform, to 1.5 mm wide; ligules 2 to 4 mm long; higher elevations .... *P. gracillima.*

Flower clusters contracted, the branches appressed, or somewhat spreading during the flowering period, at least some spikelet-bearing to near base.

Stems 10 to 80 cm high, from a dense tuft of short basal leaves; leafblades 1 to 2 mm wide; flower clusters 2 to 12 cm long; lemmas generally crisp-hairy at base or sometimes merely strongly roughish.

Stems 20 to 40 cm high; sheaths usually roughish; lower and middle elevations, Pacific slope .... *P. scabrella.*

Stems 10 to 30 (60) cm high; sheaths usually smooth; middle and higher elevations, Pacific slope and Rocky Mountains .... *P. secunda.*

Stems 50 to 120 cm high, tufted but the leaves not usually conspicuously basal; flower clusters (6) 10 to 20 cm long; lemmas roughish or finely crisp-hairy on lower part of back; middle elevations, Pacific slope and Rocky Mountains.

Ligules 2 to 5 mm long; sheaths somewhat roughish to nearly smooth; lemmas nearly glabrous or crisp-hairy.

Leafblades filiform, with inrolled margins, rather stiff; stems to 100 cm high .... *P. nevadensis.*

Leafblades flat or folded, 1 to 2 (3) mm wide, lax; stems to 120 cm high .... *P. canbyi.*

Ligules short, to 2 mm long; sheaths smooth; leafblades flat, 1 to 3 mm wide; lemmas nearly glabrous.

Stems to 120 cm high; leafblades flat; lemmas 4 to 6 mm long ....*P. ampla.*

Stems to 100 cm tall; leafblades involute; lemmas about 4 mm long .... *P. juncifolia.*

OCCURRENCE.—*Poa alpina:* MK, C, G, Yl, RM; *ampla:* C, Yl, RM; *annua:* MR, Yo, G, Yl, GT, GC; *arctica:* MK, MR, Yl, RM; *arida:* Yl, GC; *bigelovii:* GC; *bolanderi:* L, Yo, K, S; *brachyanthera:* MK; *canbyi* (including *P. lucida*): K, G, Yl, GT, RM; *compressa:* O, G, Yl, B, GC; *confinis:* O; *cusickii* (*P. subaristata* as to ours): Yo, Yl, GT; *epilis:* O, MR, Yo, K, S, G, Yl, GT, RM; *fendleriana:* S, Yl, GT, RM, MV, B, Z, GC; *glauca:* MK, RM; *glaucifolia:* Yl, RM; *gracillima:* O, MR, Yo, K, S, G, Yl; *interior:* Yl, GT, RM; *juncifolia:* Yl; *lanata:* MK; *laxiflora:* O; *leibergii:* Yo, K, S; *leptocoma:* MK, O, MR, Yo, G, Yl, GT, RM; *lettermanii:* MR, K, RM; *longiligula:* Yl, MV, GC; *macroclada:* MR; *marcida:* O; *nervosa* (including *P. wheeleri*): O, MR, C, Yo, K, G, Yl, GT, RM; *nevadensis:* Yo, G, Yl; *occidentalis:* RM, MV; *palustris* (*P. crocata*): MK, G, Yl, GT, RM, B; *pattersonii:* Yl, RM; *paucispicula:* MK, MR, G; *pratensis:* MK (var. *alpigena*), O, MR, C, L, Yo, K, S, Yl, GT, RM, MV, B, Z, GC; *pringlei* (*P. suksdorfii*): MR, Yo, K, S; *reflexa:* Yl, RM; *rupicola:* Yo, K, S, Yl, RM; *scabrella:* MR, Yo, S; *secunda* (*P. sandbergii*): O, MR, Yo, K, S, G, Yl, GT, RM, MV; *stenantha:* MR, C, G, RM.

BROMUS (Brome-grass, Cheat, Chess)

KEY TO THE SPECIES

Spikelets rather turgid at maturity; glumes and lemmas broad, rather abruptly blunt-pointed, the lemmas with transparent membranous margins and two short broad teeth at the tip, or scarcely toothed; first glume 1- to 3-nerved, the second 5- to 7-nerved; plants annual; stems 12 to 80 cm high ....Section BROMIUM, Chess, Cheat.

Flower clusters open, often nodding, the branches spreading or drooping; lemmas smooth or roughish, not hairy.

Leaves glabrous, or sometimes the sheaths finely hairy; lemmas glabrous, with awns 3 to 5 mm long; rare in the western parks ....*B. secalinus.*

Leaf sheaths and blades hairy, the blades less so than the sheaths; awns commonly longer, to 10 mm long. (Awns lacking in *B. brizaeformis.*)

Branches of flower clusters stiffly spreading, not flexuous; awns straight; mostly Pacific slope parks ....*B. commutatus.*

Branches of flower clusters slender and flexuous; awns twisted and divergent; found in the southwest. (Awn straight in *B. arvensis.*) ....*B. japonicus.*

Flower clusters more or less contracted, the branches erect or ascending; lemmas glabrous or hairy; awns 6 to 9 mm long.

Flower clusters somewhat open, the branches short and ascending; lemmas smooth or roughish, not hairy; not common in the parks ....*B. racemosus.*

Flower clusters closely contracted, the short branches appressed; lemmas rather coarsely hairy; California parks ....*B. mollis.*

Spikelets slender, or if broad, then not turgid, often more or less strongly flattened; glumes and lemmas tapering to a point.

First glume 1 (or 3)-nerved, the second mostly 3-nerved.

Lemmas very narrow, with sharp-pointed base (callus), tapering to a long point at the tip and usually prominently 2-toothed; awns usually more than 12 mm long; plants annual ....Section EUBROMUS.

Flower clusters contracted and somewhat head-like, usually purplish, the spikelets short-stalked, on short closely appressed branches; awns of lemmas 12 to 20 mm long; stems 15 to 40 cm high; California and southwest ....*B. madritenis;* (Foxtail Chess) *B. rubens.*

Flower clusters open, the branches longer and somewhat spreading or drooping; stems 30 to 70 cm high.

Spikelets coarse and rigid, with stiff rough awns 3 to 5 cm long on lemmas 2.5 to 3 cm long; California and southwest ....(Ripgut Grass) *B. rigidus.*

Spikelets more flexuous, with slender awns 12 to 14 mm long on lemmas 10 to 12 mm long; flower clusters commonly nodding, often purplish; widespread in the parks ....(Downy Chess) *B. tectorum.*

Lemmas broader, tapering to a pointed tip, scarcely toothed or the teeth very short; awns usually less than 10 mm long or sometimes awnless; plants perennial ....Section BROMOPSIS, Brome Grass.

Leafblades mostly narrow, 2 to 5 mm wide; ligules 1 (or 2) mm long; flower clusters drooping, the spikelets 15 to 30 mm long; first glume 1- to 3-nerved; lemmas pubescent all over back (rarely nearly glabrous), the awns 1.5 to 4 mm long; Rocky Mountains and southwest.

Stems 30 to 60 cm high; flower clusters to 10 (15) cm long; spikelets few (*B. porteri*) ....*B. anomalus.*

Stems 80 to 100 cm high; flower clusters averaging larger, with more spikelets ....*B. frondosus.*

Leafblades mostly wider, up to 10 (12) mm wide; flower clusters with branches appressed, spreading, or drooping; first glume mostly 1-nerved; lemmas pubescent mostly along margins and at base (sometimes glabrous or hairy over back); stems commonly 50 to 120 (150) cm high.

Flower clusters open, with slender spreading or drooping branches.

Flower clusters 10 to 20 cm long; leaves with ligules 3 to 5 mm long; joints of stems hairy; leaf sheaths more or less hairy; northwest.

Leafblades 8 to 10 mm wide, sparsely hairy above, rough or smooth

below; lemmas densely hairy on margins nearly to tip and on back at the base; awns 4 to 6 mm long .... *B. pacificus.*

Leafblades to 12 mm wide, more or less hairy; lemmas sparsely hairy over back, more densely so near margins; awns 6 to 8 mm long ....*B. vulgaris.*

Flower clusters 15 to 25 cm long; ligules very short and inconspicuous; leafblades, sheaths, and joints hairy or not; lemmas hairy on margins on lower ½ or ¾, the awns 3 to 5 mm long .... *B. latiglumis;* (*B. richardsonii*) *B. ciliatus.*

Flower clusters narrow with appressed branches, or the branches rather stiffly spreading during the flowering period.

Lemmas glabrous or hairy near base and along margins; awns 1 to 4 mm long.

Plants with creeping underground stems (rhizomes); flower clusters 10 to 20 cm long; Rocky Mountains, southwest, Alaska .... (*B. pumpellianus*) *B. inermis.*

Plants without creeping rhizomes; flower clusters 7 to 12 cm long; Pacific slope .... *B. suksdorfii.*

Lemmas glabrous or hairy over back; awns 5 to 7 mm long; Pacific slope .... *B. orcuttianus.*

First glume 3- to 5 (7)-nerved, the second (3) 5- to 7-nerved; spikelets 2 to 3 (3.5) cm long, mostly evidently flattened; lemmas strongly keeled, the midrib forming the "keel"; hairiness of sheaths and lemmas variable in most of the species; annuals, biennials, or perennials. Section CERATOCHLOA, mostly.

Leafblades 2 to 5 mm wide, glabrous or sparingly hairy; flower clusters 10 to 30 cm long, open with often drooping branches; lemmas awnless, or with awns to 4 mm long; southwest.

Stems stout; ligules 2 to 4 mm long; lemmas awnless or with awns less than 3 mm long; annual or biennial .... *B. catharticus.*

Stems weak, often reclining; ligules about 1 mm long; awns of lemmas 2 to 4 mm long; perennial .... *B. frondosus.*

Leafblades 4 to 12 mm wide; awns of lemmas mostly 4 to 15 mm long. (The following species not easily distinguished.)

Branches of flower clusters bearing 1 to few spikelets; awns of lemmas 5 to 10 mm long; coastal northwest.

Branches of flower cluster stiffly ascending; spikelets 3- to 6-flowered; stems 50 to 100 cm high .... *B. aleutensis.*

Branches of flower clusters drooping; spikelets 6- to 12-flowered; stems 120 to 180 cm high .... *B. sitchensis.*

Branches of flower clusters bearing several spikelets; spikelets 3- to 6-flowered; widespread species.

Awns of lemmas 7 to 15 mm long; flower clusters with spreading or drooping branches; leaf sheaths, glumes and lemmas glabrous to finely hairy; annual or biennial with stems 50 to 100 (120) cm high; ligules about 2 mm long .... *B. carinatus.*

Awns of lemmas 4 to 6 mm long; flower clusters with spreading or ascending branches; perennial species with stems commonly 90 to 125 cm high.

Leaf sheaths and blades commonly hairy throughout; glumes and lemmas coarsely hairy; stems hairy below flower cluster; ligules 2 to 3.5 mm long .... *B. marginatus.*

Leaf sheaths glabrous, smooth or roughish; glumes and lemmas glabrous; ligules about 2 mm long .... *B. polyanthus.*

OCCURRENCE.—*Bromus aleutensis:* O; *anomalus* (*B. porteri*), including var. *lanatipes:* Yl, GT, RM, MV, B, Z, GC; *arvensis:* GC; *brizaeformis:* Yl; *carinatus:* O, MR, C, Yo, K, S, Yl, GT, GC; *catharticus:* B, GC; *ciliatus* (*B. richardsonii*): MK, O, C, Yo, K, S, G, Yl, GT, RM, B, Z, GC; *commutatus:* MR, Yo, Yl, GT, MV; *fron-*

dosus: Z, GC; *inermis* (including *B. pumpellianus*): MK, G, Yl, GT, RM, MV, B, GC; *japonicus:* GT, MV, B; *latiglumis:* Yl; *madritensis:* GC; *marginatus* (*B. breviaristatus*): O, L, Yo, K, S, G, Yl, GT, MV, GC; *mollis:* Yo, S; *orcuttianus:* C, L, Yo, K, S; *pacificus:* O; *polyanthus:* Yo, G, RM, B, Z; *racemosus:* GC; *rigidus:* Yo, S, GC; *rubens:* Yo, GC; *secalinus:* G, Yl; *sitchensis:* O; *suksdorfii:* C, L, Yo, S; *tectorum:* O, MR, C, Yo, K, S, Yl, GT, RM, MV, B, Z, GC; *vulgaris:* O, MR, C, G.

MELICA (Melic-grass)

KEY TO THE SPECIES

Spikelets generally narrow and somewhat resembling *Festuca* or *Bromus,* (7) 10 to 20 cm long; stems 60 to 120 (150) cm high; reduced florets similar to perfect florets.

Lemmas distinctly awned or with a short awn-point, notched or toothed at the tip; stems not bulbous at base.

Flower clusters 12 to 25 cm long, with solitary branches rather distant and widely spreading or reflexed; lemmas glabrous, with awn 3 to 5 (10) mm long; leafblades 6 to 15 mm wide; Rocky Mountains .... *M. smithii.*

Flower clusters 10 to 15 (20) cm long, narrow with appressed or ascending branches; lemmas often with fringe of hairs on lower margins; leafblades 1 to 5 mm wide; Pacific slope parks.

Lemmas glabrous or hairy on margins below, with awns 5 to 12 mm long; anthers 2 to 3 mm long .... *M. aristata.*

Lemmas with hairy fringe on lower margins, usually short-awned, the awns fragile, less than 5 mm long; anthers 3 to 4 mm long .... *M. harfordii.*

Lemmas pointed but not awned, not notched or toothed; stems bulbous at base; leafblades 2 to 10 mm wide; flower clusters 10 to 25 cm long.

Glumes narrow, pointed at tips, not papery; lemmas hairy along the nerves on the backs; flower clusters usually narrow with appressed branches; anthers 2 mm long; Pacific slope and Rocky Mountains .... *M. subulata.*

Glumes rather broad and papery, blunt-pointed, nearly glabrous or slightly roughish; flower clusters open with spreading or reflexed branches; anthers 3 to 4 mm long; not common in the western parks .... *M. geyeri.*

Spikelets relatively broader and having tendency to appear papery; large or small.

Spikelets 7 to 20 mm long; fertile florets 2 to several.

Stems not bulbous at base or more or less swollen with a series of constrictions; glumes from half to as long as the spikelets.

Stems tufted, not swollen at base; flower clusters not branched or with few short appressed few-flowered branches; spikelets reflexed on very slender short stalks, tending to spread towards one side of the stem, breaking away from the stem below the glumes. (2 florets; glumes as long; eastern .... *M. mutica.*)

Stems 15 to 60 cm high; leafblades 1 to 3 mm wide; glumes nearly as long as the spikelet; Sierra Nevada parks at medium high elevations .... *M. stricta.*

Stems 50 to 100 cm high; leafblades 2 to 5 mm wide; glumes half to 2/3 as long as the spikelet; not common, in southern Rocky Mountains .... *M. porteri.*

Stems often with a series of slight swellings with constrictions between; flower clusters narrow, branched, with short appressed or ascending closely flowered branches; spikelets appressed on the branches, breaking from the stems above the glumes, leaving the glumes attached.

Stems 30 to 60 cm high; middle elevations in Sierra Nevada parks and Rocky Mountains .... *M. bulbosa.*

Stems 60 to 120 cm high; lower elevations in Sierra Nevada parks .... *M. californica.*

Stems with single distinctly bulb-like swelling at base; glumes not usually more than half the length of the spikelet; flower clusters rather loosely flowered; spikelets rather turgid or inflated.

Stems 30 to 100 cm high; flower clusters narrow, 10 to 15 cm long; spikelets purple-tinged; Rocky Mountain parks ....*M. spectabilis.*

Stems 60 to 100 cm high; flower clusters narrow or the branches stiffly spreading during the flowering period, 15 to 20 cm long; spikelets pale green; rare in California parks ....*M. inflata.*

Spikelets 4 to 6 mm long; fertile floret usually 1; glumes nearly as long or a little shorter than the spikelet; stems 30 to 100 cm high, not bulbous at base; flower clusters narrow with appressed branches or with spreading or reflexed branches in varieties; Sierra Nevada parks ....*M. imperfecta.*

OCCURRENCE.—*Melica aristata:* C, Yo, S; *bulbosa* (*M. bella*): K, S, G, Yl; *californica:* Yo, K, S,; *geyeri:* Yl; *harfordii:* O, Yo; *imperfecta:* Yo, S; *inflata:* Yo; *mutica:* Yl; *porteri:* RM; *smithii:* G, Yl, GT; *spectabilis:* G, Yl, GT, RM; *stricta:* Yo, K, S; *subulata:* O, MR, C, G, Yl.

SCHIZACHNE (False Melic)

OCCURRENCE.—*Schizachne purpurascens:* Yl, RM.

A Comparison of Soil, Climate, and Biota of Conifer and Aspen Communities in the Central Rocky Mountains

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That the dominant vegetation in a community influences and even controls to a considerable degree the nature of the soil, the microclimate, and the non-dominant plants and animals is well known (McDougall, 1949), but the exact extent to which different kinds of dominant plants modify the various physical and biological environmental factors within most biotic communities has received little study. The present investigation of aspen communities and coniferous communities in the Central Rocky Mountain Region (fig. 1) was conducted in an attempt to determine the various differences in soil, microclimate, and biota occurring under the influence of coniferous and broadleafed deciduous trees.

It is well established in the literature (Oosting, 1948) that the groves of aspen (*Populus tremuloides* var. *aurea* (Tides.) Daniels) found in the montane coniferous forests of the Rocky Mountain Region represent subclimax communities of the secondary sere. This ecological position in the sere can readily be established by finding remains of coniferous wood, either

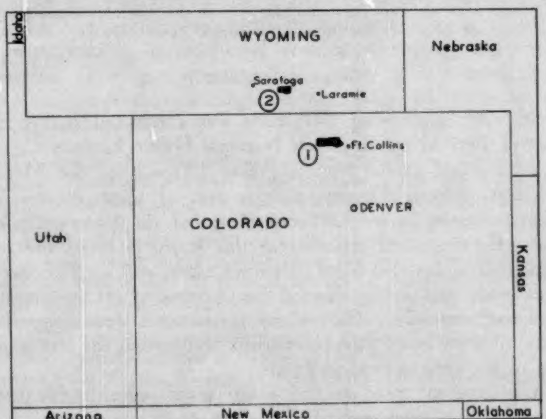

Fig. 1.—Map showing the general areas in which the field investigation was conducted. 1, Roosevelt National Forest, Larimer Co., Colo.; 2, Medicine Bow National Forest, Albany Co., Wyo.

in the form of stumps or burned fragments, in virtually every grove and by the occurrence of young climax conifers in mature stands of aspens. Based on this evidence, one may assume that at one time the areas now dominated by aspens were actually forested by conifers, these forming a continuous cover over an extensive area. Before local damage, chiefly fire, lead to the initiation of the secondary sere and dominance by aspens, it is probable that the areas now covered by aspens and the surrounding or adjacent areas forested by conifers were similar in soil, microclimate, and biota. On assuming that the present aspen covered and the neighboring conifer dominated areas were at one time actually covered by a continuous coniferous forest, it seems obvious that existing differences in edaphic and aërial factors as well as biota between aspen dominated and adjacent climax (as western yellow or ponderosa pine, *Pinus ponderosa* Doug.; Englemann spruce, *Picea engelmanni* (Parry) Engelm.; and Douglas fir, *Pseudotsuga taxifolia* (Lamb.) Brit.) or subclimax (lodgepole pine, *Pinus contorta* var. *latifolia* Engelm.) conifer areas may be attributed largely to the interactions of the dominant plants. In the present study, an attempt has been made to determine some of these differences.

At the time of initiation of this study, the writer was a member of the teaching staff of the Colorado A. and M. College. During the summer of 1947, the work was continued while the writer was teaching at the University of Wyoming Summer Science Camp. Analysis of the soil, sorting and counting the animals, and other aspects of the incident laboratory work was completed at the University of New Mexico. The writer takes this opportunity to express his appreciation to these three institutions for the use of equipment and facilities. The field work was conducted and a part of the field equipment was made available through the aid of a grant from the Permanent Science Fund of the American Academy of Arts and Sciences, to which organization the writer expresses his appreciation. The preparation of the present manuscript was aided by a faculty research grant from the University of New Mexico. Several individuals, especially my former students, Mr. Glenn A. Hutson and Mr. Dale J. Osborn, aided in the field investigations. Without the help of these two assistants, as well as the aid of the many persons who identified the animals collected, this investigation could never have been completed.

AREAS STUDIED

The field work underlying this study was conducted during the spring and summer of 1947 in the Roosevelt National Forest, Larimer County, north central Colorado, and in the Medicine Bow Division of the Medicine Bow National Forest, Albany County, a little east of south central Wyoming. Both National Forests lie in the Front Range of the Central Rocky Mountains. The general method followed in this study involved the comparison of environmental factors and biota of paired aspen and conifer covered areas, the areas of each pair being selected for continuity of topography, parent soil material, and exposure. The various paired areas were assigned numbers, these locality numbers being used consistently throughout the text in lieu of the descriptions of the geographical locations.

While the detailed areas studied were paired, considerable variation in topography, elevation, and maturity of stand of dominant trees is exhibited among the various pairs of sample plots. In spite of this, certain fundamental differences between aspen and conifer covered areas are readily observed even without detailed study. For instance, under the aspens, which often occur in thick stands, the soil is usually dark in color and covered by a thin layer

Fig. 2.—Photograph of aspen grove showing invasion by conifers. Locality 2; Feb. 16, 1947

of leaf mold, is frequently almost free from stones, and often has a thick sod formed by the roots of grasses and numerous forbs. Growths of dwarf or ground juniper (*Juniper communis* var. *montana* Ait.) and bearberry or kinnikinnick (*Arctostaphylos uva-ursi* (L.)) are common. Seedlings of climax conifers are usually found among the aspens, in the peripheral areas of young groves and invading even the center of old groves (fig. 2). In comparison and contrast, the climax and subclimax coniferous trees may be in a stand ranging from open to dense; the soil is usually light in color, contains many stones, and is dry; and a thick mat of needles covers the forest floor. Under the conifers, sparse grass may be found in open stands of trees but a sod is seldom formed.

In order to describe the variations that occur among the aspen groves and among the coniferous communities studied and in order to fix the study localities geographically, a brief and concise discussion is given for each locality sampled. For exact geographical location of each area, the reader is referred to the appropriate quadrangle of the topographic maps of the United States Geological Survey.

Locality 1, *a and b*.—Roosevelt National Forest, Larimer Co., Colo.; sec. 7, T 8 N, R 72 W, Home Quadrangle; elevation about 7,600 feet. The area lies about two miles from Cache la Poudre River along the road from Poudre Canyon to Pingree Park. The small grove, probably 100 feet wide and about 250 feet long, of aspens (fig. 3) is surrounded by yellow pines among which are a few scattered Douglas firs. Some of the larger pines, as much as 24 inches in d.b.h., bear fire scars. The aspen grove is fairly mature, with many trees at least 60 years of age, and is being invaded by yellow pines. A few small junipers (*Juniperus scopulorum* Sarg.) appear among the aspens, but these probably will fail to meet competition as the pines invade the aspens and form a closed stand. The locality was visited twice, the first time (indicated as locality 1a) on May 3 and 4, 1947, and again (designated as locality 1b) on June 17, 18, and 19, 1947. The two sublocalities differ slightly, locality 1a being better drained and subject to slightly more runoff of surface water than locality 1b.

Locality 2, *a and b*.—At Rist Canyon Camp Ground, Roosevelt National Forest, Larimer Co., Colo.; sec. 26, T 8 N, R 71 W, Livermore Quadrangle; elevation about 7,500 feet. This locality is along the Rist Canyon Road, about two and one-half miles east of Stove Prairie. Studies were made on May 22, 23, and 24 (locality 2a) and again on June 20 (locality 2b), 1947. The same immediate area was studied on both

occasions. In this locality, the somewhat extensive aspen grove follows a ravine that slopes towards the northeast, while the coniferous forest of mixed yellow pine, lodgepole pine (up to 18 inches d.b.h.), and occasional Douglas fir has a more or less northern exposure. The entire area has been cut or burned over, stumps being common in both aspen and conifer areas. The aspens are rather mature, some of them being as much as 8 inches in d.b.h. and probably of an age reaching 100 years. They are being invaded to a slight degree by conifers. A few alders (*Alnus tenuifolia* Nutt.) occur mixed with the aspens. The forest floor of the coniferous forest is virtually devoid of grasses and forbs but the aspen grove is well sodded.

Fig. 3.—Photograph of aspen grove at locality 1 during spring season before leaves appeared on aspens. May 3, 1947.

Locality 3.—Roosevelt National Forest, Larimer Co., Colo.; sec. 14, T 7 N, R 73 W, Home Quadrangle; elevation about 8,700 feet; located along the Poudre Canyon and Pingree Park road, about three miles from Pingree Park; area studied on June 1, 1947. The aspen grove is immature, the trees being under four inches in d.b.h. and probably having no greater age than 30 or 40 years. Lodgepole pines dominate the surrounding coniferous area, forming a closed stand of trees up to eight inches in d.b.h. The entire area appears to have been fired as indicated by partly burned logs. A few old lodgepole pines survived the burning and still stand within the area now occupied by the aspens. Both the aspen and conifer areas slope about 15 or 20 degrees to the east of southeast; the soil is stony; grass is sparse; but the litter on the forest floor is fairly heavy beneath the trees.

Locality 4.—Roosevelt National Forest, Larimer Co., Colo.; sec. 26 or 27, T 8 N, R 71 W, Livermore Quadrangle; elevation about 7,600 feet, about one-half mile west of locality 2 along the Rist Canyon road; June 7 and 8, 1947. The aspen grove located here is fairly mature, many of the trees having a d.b.h. of as much as ten inches. The soil is dark, fairly deep, contains few rocks, and is well permeated with the roots of grasses and kinnikinnick. The aspen grove is surrounded by a yellow pine consociation, with trees reaching a d.b.h. of 18 inches. The yellow pines are on slightly higher ground with better drainage; the soil is shallow and the needle layer is as much as two or three inches in thickness; forbs and grasses are sparse. Some mountain mahogany (*Cercocarpus* sp.) occurs among the yellow pines.

Locality 5.—Roosevelt National Forest, Larimer Co., Colo.; sec. 15, T 7 N, R 73 W, Home Quadrangle; elevation about 8,800 feet; located along the Pingree Park road about two miles from Pingree Park; June 14 and 15, 1947. The area studied is located on a hillside sloping between 10 and 15 degrees to the south; the soil is shallow and stony; and there is little grass and few forbs in either the aspen or conifer occupied areas. Burned logs are common. The area is being very heavily grazed. The aspens are small, chiefly under a d.b.h. of five inches, but growth rings indicate an age of at least 45 years for many of the trees. The present coniferous forest consists of an almost pure and somewhat open stand of lodgepole pines, ranging from six to 14 inches in d.b.h.

Locality 6.—Roosevelt National Forest, Larimer Co., Colo.; sec. 36, T 8 N, R 73 W, Home Quadrangle; elevation about 8,000 feet; located about one and one-quarter miles north of Fish Creek Camp Ground on the Poudre Canyon to Pingree Park road, on east side of South Fork Cache la Poudre River; June 15 and 16, 1947. The area is dissected by gullies running in general east and west. The aspens occur for the most part along

the sides and in the bottoms of the gullies, while yellow pines (sometimes as great as 20 inches in d.b.h. and bearing fire scars) with a few scattered lodgepole pines, Douglas firs, and blue spruce (*Picea pungens* Engelm.) form an open stand on higher areas between gullies or ravines. The aspens are often eight or nine inches in d.b.h., having probably an age of at least 70 years. They occur in a dense and closed stand, but show some invasion by yellow pines and more especially by blue spruce. The soil of the aspen covered area is well sodded; the soil of the coniferous area is shallow and without sod.

Locality 7.—Roosevelt National Forest, Larimer Co., Colo.; sec. 24, T 8 N, R 73 W, Home Quadrangle; elevation near 8,000 feet; located about one-half mile south of Bennet Creek Camp Ground along the road from Poudre Canyon to Pingree Park; June 16 and 17, 1947. In this locality, the aspens occur in small, semi-isolated groves of dense stand incompletely surrounded by somewhat open stands of spruce, Douglas fir, and yellow pine, which often include trees of 12 to 18 inches d.b.h. The aspens are small, few being more than two inches in d.b.h., but at the same time some of them appear to have considerable age since one aspen with a diameter of less than two and one-half inches had 56 growth rings. Douglas fir and yellow pine seedlings occur frequently among the aspens. The entire area has a slope of 20 to 25 degrees, with exposure to the north and northeast.

Locality 8.—Roosevelt National Forest, Larimer Co., Colo.; sec. 7, T 8 N, R 72 W, Home Quadrangle; elevation about 7,700 feet; just across the road and at a slightly higher elevation than locality 1; June 18 and 19, 1947. In this locality the aspen grove lies in a gully running from northwest to southeast. The presence of climax coniferous forest stumps within the aspen grove indicates a former stand of mature conifers. The grove is fairly mature, since the aspens have a maximum diameter of seven inches, but most of them are smaller. The aspens are being invaded by junipers (*Juniperus scopulorum* Sarg.) and a few yellow pines. The soil beneath the aspens is dark in color; there is considerable grass and some forbs, with an abundance of kinnikinnick. The conifers bordering the aspen grove at the sides of the gully and continuing to the tops of ridges consist of yellow pines, some as much as 18 inches in d.b.h., with a few scattered cedars or junipers. Beneath the open stand of conifers the soil is stony, but there is considerable grass and some mountain mahogany in open areas between the larger trees.

Locality 9.—Medicine Bow National Forest, Albany Co., Wyo.; sec. 13, T 16 N, R 79 W, Medicine Bow Quadrangle; elevation 9,900 to 10,000 feet; located across the highway from the University of Wyoming Summer Science Camp; June 30 and July 1, 1947. According to tradition, this area was burned by a very extensive forest fire about 1870 (Blake, 1945). The remains of many of the trees of the former coniferous forest are still evident in the form of snags, stumps, and jumbled masses of fallen trunks. Following the fire, a greater part of the area developed into a lodgepole pine community and a smaller area developed into an aspen community. These aspens are growing at the highest elevation observed during the course of this investigation. The area previously has been given some ecological consideraton by Blake (1945). The aspens occupy a boulder strewn area with a slope of 10 to 15 degrees to the south. Most of the aspens are small, less than four inches in d.b.h., although some reach a d.b.h. of seven or eight inches and an age of about 70 years. The aspens are being invaded around the periphery of the stand by Englemann spruce and alpine fir (*Abies lasiocarpa* Nutt.), but as yet there is virtually no invasion into the center of the grove. The conifer covered area studied was slightly above and to the west of the aspen grove where the slope is, however, very similar to that of the aspen occupied area. The conifers are chiefly lodgepole pines up to 12 or 15 inches in d.b.h., but in some areas these subclimax trees are being invaded by climax Englemann spruce, some of which have already reached a diameter of six to eight, rarely 12, inches. Under the aspens, the shallow soil and aspen litter lies chiefly between large boulders. Some grass is present and there is considerable ground juniper. In general, the stony and shallow soil beneath the lodgepole pines bears a sparse growth of grass.

Locality 10.—Medicine Bow National Forest, Albany Co., Wyo.; sec. 19, T 16 N, R 78 W; altitude about 9,400 feet; area located along the south side of the highway about one and one-half miles southeast of locality 9; July 7 to July 9, 1947. This area is topographically very rough, with a 15 to 30 degree slope to the south and southwest; the ground is boulder strewn or very stony; and there is considerable fallen timber. The

aspen grove is fairly mature with the largest aspens between eight and nine inches in d.b.h. The coniferous forest is composed of a close stand of lodgepole pine, that, for the most part, is being replaced by spruce and fir. Both lodgepole pine and spruce may reach a d.b.h. of nearly 12 inches. In the aspen area, there is an accumulation of leaf mold between the boulders, with a little grass, some roses (*Rosa* sp.), ground juniper, Oregon grape (*Berberis aquifolium* Pursh) and bilberry (*Vaccinium* sp.). Grass is virtually absent from the area dominated by conifers.

Locality 11.—Medicine Bow National Forest, Albany Co., Wyo.; sec. 29, T 16 N, R 78 W; elevation 8,900 to 9,000 feet; area located just northeast of the highway and about one mile southeast of locality 10; July 15 and 16, 1947. In this area, a more or less pure stand of lodgepole pine is located down slope from a fairly mature stand of aspens, the former community being on a slope of not over five degrees, the latter on a hillside with a southeast slope of about 20 or 25 degrees. A number of fire-scarred and partly burned stumps and coniferous logs indicate that the aspens are growing in a burned over area. The forest floor in the aspen grove is well covered by grasses but these are virtually absent beneath the pines.

Locality 12.—Roosevelt National Forest, Larimer Co., Colo.; sec. 6, T 7 N, R 75 W, Home Quadrangle; elevation about 9,300 feet; located just northwest of Chambers Lake along the road to Glendevey; July 27 and 28, 1947. The aspen grove at this locality is small, measuring about 150 feet in length by 100 feet in width, consisting of trees one to four inches in d.b.h., and almost completely surrounded by a stand of lodgepole pines. Old stumps and logs among both aspens and pines indicate a former climax forest that was destroyed by fire. A few small Englemann spruce trees are invading the lodgepole pine community and one small fir and a few small spruces were found among the aspens. Under the aspens, the damp soil was covered by a layer of leaf mold about one-half inch in thickness and supported a few forbs and some ground juniper. In the lodgepole pine community, a needle layer one to one and one-half inches deep covered the dry, gray soil.

Locality 13.—Roosevelt National Forest, Larimer Co., Colo.; sec. 32, T 8 N, R 75 W, Home Quadrangle; elevation 8,800 feet; near the highway about one mile northeast of Chambers Lake along the road to Big South Camp Ground; July 28 and 29, 1947. The aspen covered area here is more or less surrounded by a lodgepole pine community, the two communities occurring on burned over areas of very similar topography. The aspens form a dense stand of trees from one to eight inches in d.b.h.; the leaf litter is fairly deep, often as much as one or two inches; there is little grass; and there is virtually no indication of invasion of the grove by climax trees. The surrounding coniferous forest consists of an almost pure and somewhat open stand of lodgepole pines, with trees up to 12 and 14 inches in d.b.h. Under the lodgepole pines there is a thick layer of one or more inches of needles; the soil is stony and dry; and grass is even more sparse than among the aspens.

Locality 14.—Roosevelt National Forest, Larimer Co., Colo.; sec. 2 or sec. 11, T 8 N, R 75 W, Home Quadrangle; elevation about 7,900 feet; at Sleeping Elephant Camp Ground on the Cache la Poudre River road; July 29 and 30, 1947. This locality differs from other areas studied since the stand of conifers consists chiefly of junipers (probably *Juniperus scopulorum* Sarg.) growing on very rocky soil. The aspens are fairly large, up to eight inches in d.b.h. Beneath the aspens, there is frequently a good growth of grass with some Oregon grape and some small sagebrush (*Artemisia* sp.). The junipers cover a small and topographically very rough area, but the stand is fairly thick and consists of trees up to 40 feet tall. Beneath the junipers, the soil is dry, grass for the most part is absent, but large sagebrush (*Artemisia* sp.) is fairly common. Some ground juniper is also present. That the junipers are not the climax is evident from the occurrence of pine logs among the junipers and some invasion by Douglas fir.

Locality 15.—Roosevelt National Forest, Larimer Co., Colo.; sec. 28, T 9 N, R 74 W, Home Quadrangle; elevation about 7,900 feet or 8,000 feet; located about four miles northeast of locality 14 and north of and about 200 feet higher than the Cache la Poudre River road at this point; July 30 and 31, 1947. The area has a slope of about five degrees to the south and has been much disturbed by cutting and burning. The aspens

studied occupy a central position in a gully with the conifers along the sides and at the mouth of the gully. Many of the aspens are old, with a d.b.h of as much as 14 inches. The aspen litter is very deep; there is virtually no grass but a few forbs are present. The conifer area studied is dominated chiefly by yellow pines, some of which are as much as 32 inches in d.b.h. There is a needle layer of two or three inches in depth covering the somewhat stony soil. Grass and forbs are chiefly absent beneath the yellow pines.

AERIAL OR CLIMATIC DIFFERENCES

As a part of the present study of conifer and aspen communities, an attempt was made to discover aerial or climatic differences that might result from differences in dominant plants in the two communities. In general, an effort was made to study such climatic factors as light, rate of evaporation, relative humidity, and daily maximum and minimum temperatures. Since the nature of the field procedures and the limited time available precluded observations relative to such climatic standards as annual precipitation, annual mean temperature, and the like, the reader is referred to the data given by Baker (1944).

Light.—Light intensities were measured in foot lamberts by means of a General Electric exposure meter, type DW-58. Light intensities were determined by pointing the meter skyward, being careful to avoid direct light from the sun, and thereby measuring the amount of light reflected from the sky and received through the crown of trees. The meter was also directed downward, at right angles to the surface of the soil, thus determining the amount of light reflected from the ground. The results of 20 sets of multiple data from 15 localities indicate that there is no consistent difference between the amount of light in the aspen groves and in the conifers during the growing season when the aspens are in leaf. While it is true that the amount of light reflected from the ground and the amount reflected from the sky are less in some aspen groves than in the adjacent coniferous forest, this is in no wise the general rule. The data secured do not substantiate the general impression that the greater development of herbaceous vegetation on the forest floor of the aspen groves is due to greater light intensity during the time the aspens are in leaf. Very probably the increased vegetation may be attributed to the much greater soil moisture in the aspen groves and the presence of more light in the aspens than in the conifers during the spring and fall, before and after the aspens are in leaf.

Relative humidity.—Relative humidity was determined by means of a sling psychrometer. During the course of this study, 45 sets of multiple data were secured from the 15 areas. In general, relative humidity was found to be below 50%, with occasional readings as low as 10% and, following rains, as high as 95%. No consistent difference could be detected between the relative humidity of aspen and conifer areas. In the majority of the sets of data, only slight differences were found but, due probably to topography and air currents, relative humidities sometimes differed by as much as 25% between the two contrasting communities.

Air temperature.—Air temperatures were taken with Taylor Six's maximum and minimum self-registering thermometers mounted on stakes driven into

the soil. These thermometers were placed with the center of the mercury column about one foot from the surface of the soil and in such a way that the mercury column was shaded from direct rays of the sun by the stake supporting the thermometer. In each locality, three instruments were placed among the aspens and three in comparable situations among the conifers, an average of the three thermometer readings being used for comparing data from the aspen and conifer areas. Results based on maximum, minimum, and average temperatures (derived from maximum and minimum thermometer readings) as well as daily range give no indication of a consistent difference between the two types of communities studied. The lowest temperature, 28° F, was encountered in the lodgepole pine subclimax on the night of June 30 at locality 9 and the highest, 96° F, was found in a juniper community at locality 14 on July 29. The data show that for the maximum, the aspens are from six degrees higher to five degrees lower than the coniferous areas, while the minima show less range, the temperature in the aspens being from 4.3° higher to 4.7° lower than the temperature in the conifers. There are about as many temperature values from the aspens above as there are below those from the areas occupied by conifers. On studying the average temperatures, it is found that the aspen groves have a temperature from five degrees warmer to three degrees colder than the coniferous areas, with a few more of the paired sets of data showing the aspen areas warmer than the coniferous areas. With respect to daily range, this was usually from 35 to 50° F, as is to be expected in mountainous regions. On comparing the daily temperature range among aspens and conifers, the aspen areas show a range from 6.3° greater to 7° less than the range among the conifers. In five instances, the range was less in the aspens, while in eight instances the range was greater. In only four instances was the difference in the range between the two samplings of a pair greater than 3° F. From these data, in which there appear to be no particular and consistent differences, one is inclined to assume that temperature differences between conifer and aspen areas are not due to dominant vegetation but are associated with differences in topography.

Evaporation.—In each locality, the rate of evaporation was determined by placing three standardized Livingston white spherical atmometers, one accompanying each maximum and minimum thermometer, among the aspens and three among the conifers. The atmometers were placed about 10 inches from the ground level in order to register more satisfactorily the rate of evaporation that might influence the herbaceous vegetation and the soil invertebrates. In each locality, the atmometers were operated for 21 to 23 hours, the length of time being determined by the time needed each day to move the equipment to a new locality. Data used in comparisons between communities are based on the average of the readings of the three atmometers after application to each of the coefficient of correction. Data were secured from only 11 localities, since atmometers were not available during the first part of the investigation and since some readings were discarded because of rain, the atmometers not being equipped with check valves. The absolute data show that the evaporation rate in the conifer areas ranged from 0.785 cc/hr to as much as 1.495 cc/hr, while the range in the aspen groves was from 0.735 cc/hr to 1.710 cc/hr. With respect to differences in evaporation rate between the

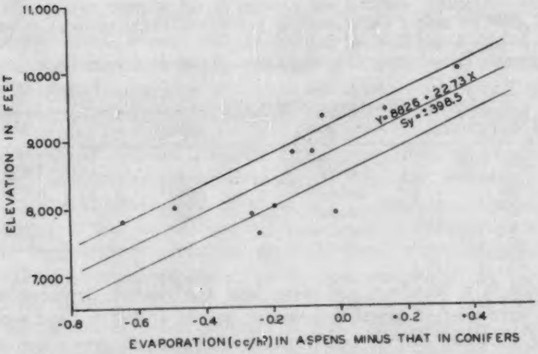

Fig. 4.—Graph showing the relationship of elevation and differences in evaporation rates in aspens and conifers. The regression line was computed by the method of least squares. Sy = the standard error of estimate.

aspen and conifer communities, it was found that at low elevations greater evaporation occurred in the conifers than in the aspens while the reverse, with less evaporation among the conifers, is true for higher elevations. This general trend, which is depicted in fig. 4, can no doubt be explained on the basis of differences in density of stand. At low elevations, the conifers are often in an open stand while the aspen groves consist usually of well-developed trees in a more or less closed stand. This tends to reduce the velocity of the wind within the aspen groves and, in turn, directly reduces the rate of evaporation. At high elevations and on rugged slopes, the two often being correlated, the aspen stand is frequently more open than the stand of conifers and, as a result of increased air movements among the aspens, there is decidedly more evaporation in the aspen groves.

SOIL OR EDAPHIC DIFFERENCES

Soil origin and texture.—In all areas studied, the soil is derived from igneous and metamorphic rocks, since the aspens are not found at lower elevations where parent soil materials are often sedimentary rocks. In general, the soil is shallow, sometimes eroded, and with frequent outcroppings of parent rock. In a few of the localities studied, the soil is evidently an alluvium of very local origin. Regardless of the topography of the area, the soil in aspen groves is invariably deeper and less rocky than the soil occupied by conifers, the differences between soils of the two communities evidently becoming greater as the aspen grove becomes more mature. In order to determine the relative amounts of fine earth (particles less than 2.0 mm in dia.) in relation to the larger particles, gravel and pebbles, in the surface soil, three samples of soil, each 1/5 sq. ft. in area and two inches deep, were taken in the aspens and the same in the pines at four localities. The fine earth (particles less than 2.0 mm in dia.) was removed from the samples by

TABLE 1.—Amounts of coarse soil particles in soil of aspen and conifer communities. Content is given by weight (in grams) of gravel and coarse particles in soil samples of 3/5 sq. ft. and 2″ deep (1/10 cu. ft.).

Locality	Development of aspen grove	Coarse particles	
		aspen	conifer
1a	mature	121.5	330.5
2a	mature	406.0	947.0
3	immature	518.0	531.0
4	mature	75.5	1105.0

sifting through a standard soil sieve and the coarser particles, retained on the sieve, were washed, dried to constant weight at 105°C, and weighed. The contrasting amounts of this coarse material for aspen grove soil and for the soil beneath conifers are indicated in table 1. It is apparent that as the aspen grove ages, the coarser particles become buried by fine earth resulting from an accumulation of vegetal debris and the reactions of soil animals. In addition, the soil often becomes well sodded and the vegetation tends to prevent erosion and holds the finer soil particles.

During the course of the study, soil samples were obtained for the express purposes of determining soil moisture, organic matter, and soil texture. Each sample was a composite sample secured by taking a trowelful of soil from five points selected at random in the community, mixing the soil together in a sieve having a mesh of 2.0 mm, and using as a sample the material shaken through the sieve. The samples were taken at a depth of one to three inches, this depth being considered pertinent as far as the distribution of soil invertebrates is concerned. The samples were returned to the laboratory in tightly sealed screw cap jars of a capacity of eight ounces. After determining the moisture content of the individual samples, as indicated under the discussion of soil moisture, the samples were used for determination of soil texture and organic carbon.

The soil texture was determined by the hydrometer method using standard equipment and following the procedure of Bouyoucos (1936). The soil was found to be almost without exception a sandy loam. In the aspen groves, the sand (particles 2.0 to 0.05 mm in dia.) varies from 36.6 to 76.7%, silt (particles 0.05 to 0.002 mm in dia.) varies from 17.4 to 47.7%, and the clay (particles less than 0.002 mm in dia.) ranges from 4.9 to 23.2%. In the conifers, the range for sand is 45.2 to 78.1%, for silt 16.85 to 45.65%, and for clay from 4.4 to 11.4% In many of the paired samplings, the values for aspen and conifer soils hardly differ beyond the limits of instrumental or sampling errors, but in a few instances, chiefly where there is marked erosion or deposition, there are significant differences between the soil texture of the two types of communities under consideration. The data indicate that there is a slight tendency for more clay and silt and less sand in the aspen than in the conifer soil, but this is not consistently true for all samplings and probably not sufficiently marked to have an effect on the biota. In the 17 sets (two localities were sampled twice) of data secured, 13 sets show at least slightly more sand in the conifer soil while 12 samples show less silt and eight show

less clay in the conifer soil than in the aspen soil. There is some indication of a possible correlation of soil texture differences and elevations, there being greater amounts of sand and larger amounts of silt at lower elevations while there is less sand and more clay at higher elevations. The small number of samples, however, precludes a statistical expression of this observed trend.

Soil moisture.—In the soil of each aspen grove and adjacent coniferous forest studied, determinations were made of the soil moisture. Samples collected as explained above were dried at 105° C and the amount of water lost determined. It was found that soil moisture was exceedingly variable in the different localities, as might be expected from the randomness of the sampling. The moisture, expressed as the percentage of dry soil weight, varied from 7.66% to 25.27% in the soil of conifer areas and from 13.33% to 61.56% in the soil of aspen groves. It was found that, in spite of variations in the absolute values involved, the soil moisture was consistently higher in the soil of aspen groves than in the soil of adjacent coniferous forest areas. This is shown in fig. 5. No attempt was made to correlate soil moisture and either elevation or season; although it is well known that the soil moisture has a tendency to increase with elevation.

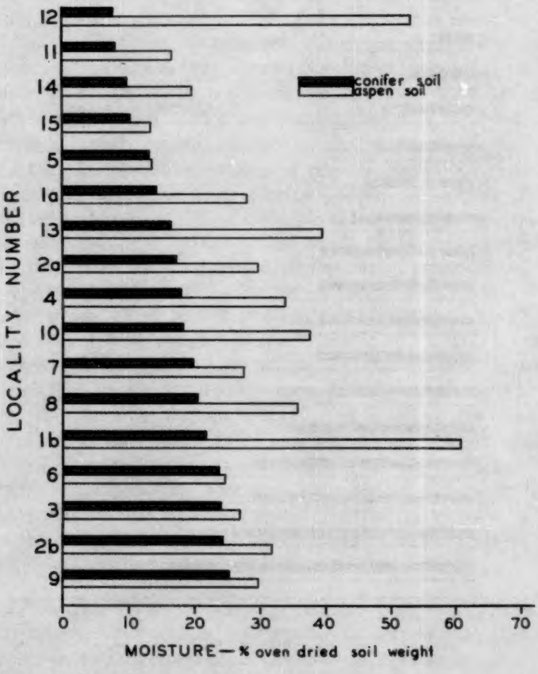

Fig. 5.—Soil moisture in paired samples from aspen groves and conifer communities

Soil pH.—The pH of the soil was determined with a La Motte soil set using bromthymol blue and phenol red as indicators. Samples were taken at three points at a depth of about two inches in the mineral soil of the aspen grove and again at three points in the adjacent coniferous forest of each locality. In comparing the results of the testing in aspen groves and coniferous forest, the average of the three samples has been used. The actual variation or range found in the three samples in either the aspen or the conifer community at any given locality was small, seldom exceeding 0.2 of a unit of pH. It was found, as shown in fig. 6, that the soil of the conifer communities ranged from a pH of 6.3 to 7.1 and in the aspen groves the pH ranged from 6 6 to 7.4. In the 16 sets of data (locality 1 was sampled twice) secured, the aspen soil showed a pH of 0.1 to 0.5 units greater than the soil of the neighboring conifer communities in 15 sets of the data. In locality 7 the pH was found to be the same in the two communities. This exception of an otherwise general rule occurred in an area where the aspens are found in small, semi-isolated groves of small trees surrounded by climax conifers. From the data one would surmise that an increased amount of dissolved salts due to more rapid turnover and the nature of the organic debris in the soil of aspen groves serves as a basic buffer and brings about a slightly higher pH.

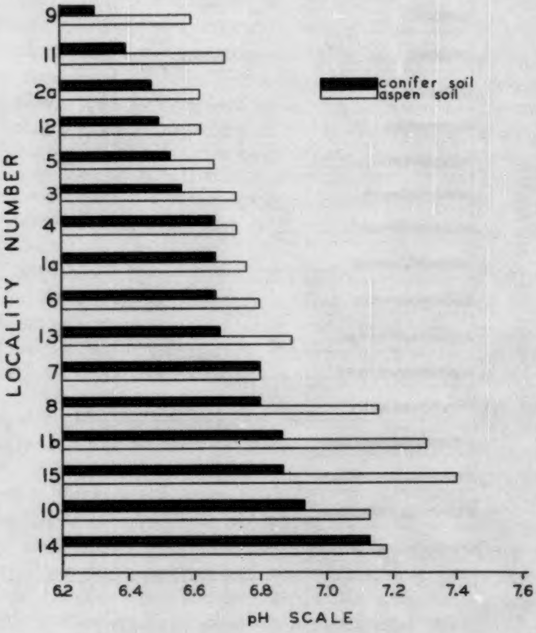

Fig. 6.—Comparison of pH in paired samples of aspen and conifer soil

This has been noticed by other observers (Lutz and Chandler, 1946) in regard to the soil beneath coniferous and broad-leafed deciduous trees. From the data, no correlation is evident between alkalinities and the altitudes of the areas sampled. In addition, there appears to be no definite correlation between elevation and the degree of difference between the pH of conifer and aspen soils. There does appear to be, however, a tendency towards an increase in the difference between the two communities as the growing season advances, but this trend can hardly be considered more than a slight indication because of the small amount of data presented here.

Organic carbon.—Organic carbon content of the conifer and aspen soil was determined for each of the 15 localities studied, with each of localities 1 and 2 being sampled twice. The method used for determination of organic carbon was the oxidization of the organic matter in a known quantity of soil by use of a specific amount of chromic acid in the presence of sulphuric acid, with titration of the unused chromic acid by 0.2 N ferrous ammonium sulfate, using diphenylamine as an indicator (Schollenberger, 1945). The organic matter content could not be determined by the ignition method since large amounts of charcoal are invariably present in the soil. In the soil of the aspen groves, the organic carbon content varied from 0.51% to more than 10.0% and the organic carbon of the soil of the coniferous forest ranged from 0.52% to 3.55%. In every instance but three, the organic carbon content of the soil from aspen groves was appreciably higher, from 1.6 to 7.0 times greater, than that of the coniferous soil. In the three instances where significant differences were not found, one locality had 1.01 and the other two had 0.98 times as much organic carbon in the aspen as in the coniferous areas. The results of the determinations of organic carbon are given in fig. 7. In no way does the organic carbon content of the soil appear to be correlated with soil texture or even pH. Neither is there a relationship to elevation. This lack of relationships is probably the result of the immature nature of the soil, with erosion in some areas and deposition in other areas. There is, however, a distinct correlation (coefficient of correlation, $r = .7574$; coefficient of determination, $r^2 = .5734$) between soil moisture and organic carbon and there is a still greater correlation ($r = .9098$; $r^2 = .8277$) between the degree of difference in moisture (expressed as the ratio between the moisture in the aspens and that in the conifers) in the two types of communities and the degree of difference in organic carbon (expressed as the ratio between the organic carbon in the aspen groves and that in the conifer communities) in the two types of communities, as shown in fig. 8. It is evident that those paired samples from localities showing the greatest difference in organic carbon content between the two samples of the pair, also show the greatest difference in the soil moisture. One may surmise that the organic matter of the soil is important in the retention of soil moisture.

Soil temperatures.—In an effort to determine possible differences in soil temperature between aspen groves and coniferous communities, soil temperature data were secured by means of chemical type thermometers, of which three were placed in a temporary pit or well in the aspen grove and a similar set was placed in the coniferous forest adjacent to the grove in each locality.

TABLE 2.—Direction of the differences between air and soil temperatures in the aspen groves and the adjacent coniferous communities

	Number of sets of data in which the temperatures of the:		
Temperature of	conifers are higher	aspens are higher	equal in two communities
air	15	23	8
subsurface	24	16	6
two inches in soil	27	19	0
one foot in soil	19	21	6

Immediately after a well was dug, the thermometers were placed in the soil of the side of the well in a position parallel to the surface of the soil and at depth just beneath the surface, at two inches, and at one foot. The well was then covered with a board and this in turn was covered by soil to serve

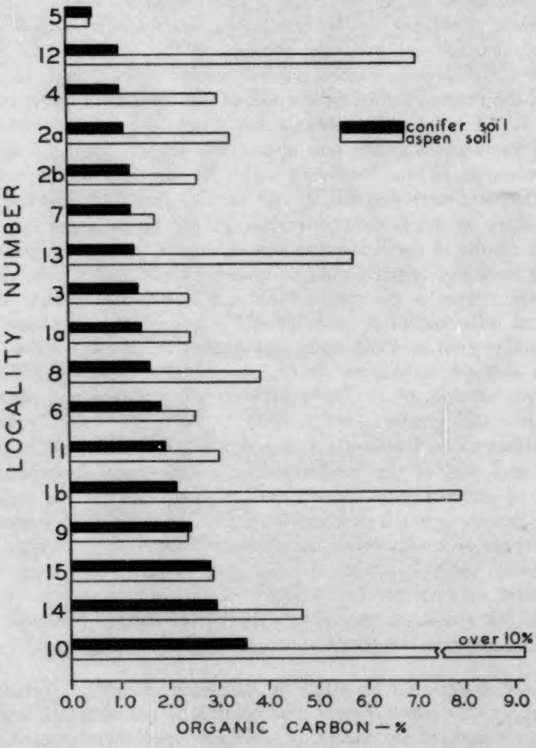

Fig. 7.—Organic carbon content of paired samples of soils from aspen and conifer communities

as an insulator. Readings were taken from wells in both communities at nearly as possible the same time, and, along with these, air temperatures were recorded. Forty-six sets of data were secured from the fifteen localities.

An attempt to analyze the mass of data and draw general conclusions ended in such confusion that one is lead to believe that factors such as slope, exposure, air temperature, and the like actually control the differences in temperature of the soils of the two communities. As indicated in table 2, neither the pines or aspens are consistently warmer either with respect to air temperature, subsurface soil temperature, or the temperature at greater depths. While the data do show the trends of soil temperature at various depths as a function of the seasonal advance and do indicate the relationship of air and soil temperatures, these have no relationship to our present study and are not discussed here.

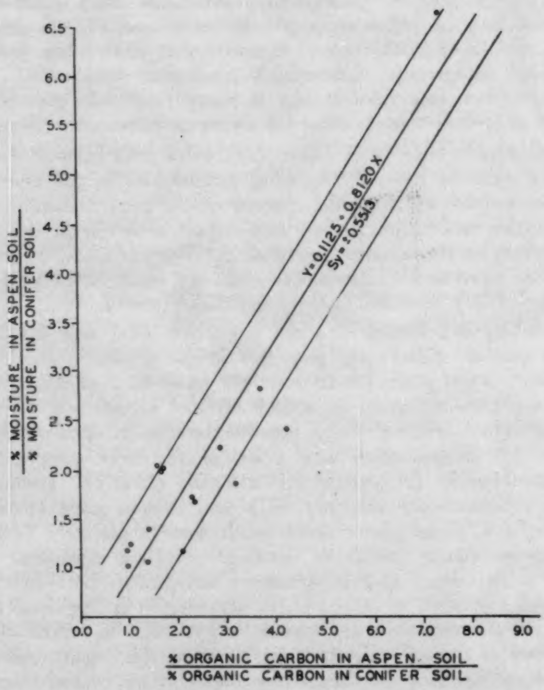

Fig. 8.—Graph showing the relationship in the samples of each pair with respect to degree of difference in soil moisture and organic carbon in the aspen and conifer soils. The regression line was computed by the method of least squares. Sy = the standard error of estimate.

FLORA

During the course of this study, little attention was given to the aspens themselves since Baker (1925) has discussed in detail the aspens of central Utah. Most of his observations appear applicable to the aspens of groves considered in the present study, except that the aspens studied by Baker form extensive groves covering much greater areas than do the aspens considered here. In the Front Range of the Rocky Mountains, the aspens usually occur in small and somewhat isolated groves. Since the aspens are found in such small groves, there occurs a much more rapid invasion by climax conifers so that the aspens are crowded out by climax conifers before they attain the age and size common in central Utah. In the present investigation, increment cores were taken from aspens in several localities in an effort to determine the possible ages of present aspen stands. In most groves, the larger trees, seven to eight inches in d.b.h., are about 70 years of age, but there is evident a considerable amount of variation in growth rate under different environmental conditions. A reduction in growth rate is especially noticeable at high elevations and in areas that are rocky, somewhat eroded, and well drained due to rough topography. Under such conditions, trunks with a d.b.h. of less than one inch may have an age of thirty years. In general, however, the age of individual trees bears about the same relationship to trunk d.b.h. as that indicated in table 12 by Baker (1925) for trees from central Utah.

Since a study of the soil inhabiting invertebrates in the aspen and the conifer communities was the chief concern of the present investigation, only a brief mention will be made here with respect to a few of the more conspicuous plants of the communities studied. For additional information on the plants of aspen and conifer communities, the reader is referred to papers by Ramaley (1927), Costello (1944), and Blake (1945).

A precursory examination of aspen groves will show that the forest floor supports a number of forbs and grasses, although in some groves the density of such plants is not great. In contrast, the forest floor of the conifer dominated areas is usually covered by a thick layer of needles and the growth of grasses and forbs is minimal except between the trees in open stands at lower elevations. In addition to grasses, a few of the more conspicuous plants include kinnikinnick (*Arctostaphylos uva-ursi* (Linn.)), ground juniper (*Juniperus communis* var. *montana* Ait.), and Oregon grape (*Berberis aquifolium* Pursh). These plants occur much more abundantly in the aspen groves than in mature stands of conifers. At low elevations, mountain mahogany (*Cercocarpus* sp.) is sometimes conspicuous between the yellow pines in open stands. The various plants occurring in greater density in aspen than in conifer communities are apparently important in contributing to the organic matter of the soil. By its intrinsic nature, this organic debris decomposes more readily than do the needles of the litter beneath the conifers. Frequently roots are found to form an interlacing mass among the aspens, but this is seldom true with respect to the conifers. Mats of sod such as are found in many of the well-developed aspen groves, along with increased organic matter, apparently have considerable effect on the numbers and distribution of some of the soil invertebrates.

FAUNA

Soil invertebrates.—A study of the soil invertebrates was an integral part of the present investigation. At the initiation of the study, an attempt was made to secure data on both the microinvertebrates and the macroinvertebrates of the soil and litter, the former being collected by the use of Berlese funnels and the latter by sifting. Due to the difficulties associated with the use of Berlese funnels without daily contact with a permanent laboratory, only a few collections of the microinvertebrates were made. A more detailed and extensive survey of the macroinvertebrates was carried out at each of the study localities.

Microinvertebrates.—In sampling soil for microinvertebrates, Berlese funnels were used for isolating the organisms from soil and litter. Samples were taken by a sampling ring of six inches in diameter and two inches deep, this giving a sample from an area of approximately one-fifth of a square foot. The ring was driven into the mineral soil to a depth of two inches, that is, until the top edge of the ring was at a level with the surface of the mineral soil, and the included litter and soil were then removed to Berlese funnels. In the localities sampled, three 1/5 square foot samples were taken from the coniferous area and three from the aspen area. While the data include only the organisms found in the upper two inches of the soil and in the litter, the lack of deeper sampling should not disturb radically the ratio between the numbers of individuals in the two kinds of communities studied. It must be understood that the Berlese samples contained not only the microinvertebrates, defined as animals too small to be collected ordinarily by sifting, but also the macroinvertebrates, that is, those animals that are collected easily by sifting the soil. Since the macroinvertebrates are considered elsewhere, only the microinvertebrates found in the Berlese samples are discussed here.

One set of data was secured from collections made on May 4, 1947, at which time three one-fifth square-foot samples were taken from a yellow pine community and three from an aspen community at locality 1a. In the sampling from the pines, there was a total of 494 soil invertebrates of which 475 were microinvertebrates; in the neighboring aspen community, a total of 486 invertebrates were taken and of these, 461 were microinvertebrates. A second study was made on May 24, 1947, at which time three samples were secured from a mixed coniferous community and three samples from an aspen community at locality 2a. In the pine community, a total of 738 soil invertebrates were secured in contrast to a total of 546 from the aspen area. Of the invertebrates from the pine community, 714 were microinvertebrates and, from the aspen community, 449 were microinvertebrates. A partial breakdown into major groups is given in table 3.

From the table, it is evident that the soil microarthropods consist chiefly of mites and of Collembola of the suborder Arthropleona and that these are about equally abundant in both the conifers and the aspens. It is of interest, although not conclusive due to meager sampling, to note that Collembola of the suborder Symphypleona are found only in the coniferous soil and litter, while very small, almost minute, soil inhabiting pseudoscorpions,

TABLE 3.—Numbers of various groups of microinvertebrates in samplings of approximately 3/5 sq. ft. and to a depth of 2 inches

Group	Locality 1a aspens	Locality 1a conifers	Locality 2a aspens	Locality 2a conifers
Collembola, Symphypleona	0	7	0	2
Collembola, Arthropleona	37	87	64	48
Thrips	0	0	0	4
Psocids	0	0	0	2
Pseudoscorpions	0	0	3	0
Mites, trombidiid	8	1	2	4
Mites, oribatid (galumnid)	144	136	380	654
Mites, others	272	244		
TOTALS	461	475	449	714

as indicated both by the present data and by a large amount of more recent and additional data in the possession of the writer, are found typically in aspen grove soil and not in the soil of coniferous stands.

Macroinvertebrates.—The soil macroinvertebrates were secured by slowly sifting surface litter and soil of an area of one square foot and to a depth of two inches in the mineral soil through a sieve of hardware cloth of one-fourth inch mesh onto a white cloth, from which the invertebrates were carefully removed to alcohol by means of an aspirator or forceps. For purposes of study, the collections from litter were made separately from collections from the soil, although for purposes of reporting the data here, the soil and litter forms have been combined. The sampling in most localities included two one-foot square samples from the conifer stand and the same from the aspen community, although time in some instances precluded a sampling of more than one square foot from each community. In order to conserve time, samples to depths greater than two inches were not taken, but the author has data to show that while deeper sampling would change the absolute numbers of macroinvertebrates as referred to unit areas, the ratios between the macroinvertebrates of the aspen and those of the conifer communities would not be radically changed.

While the data concerning the numbers of macroinvertebrates in litter and in the underlying soil were secured, the data, perhaps as a result of sampling without regard to season or time of day, are so variable and undecisive that they are not given here in detail. However, it is evident that on the average about twice as many individuals are found in the upper two inches of mineral soil as are found in the overlying litter in the aspen groves, while the numbers in the upper two inches of soil and in the litter are approximately equal in the conifers. This is what may be expected in view of the much greater thickness of litter on the floor of the coniferous forest.

For purposes of comparing the numbers of macroinvertebrates in the soil and litter of aspen groves with the numbers in the soil and litter of the conifer communities, each collection from the soil was combined with the respective collection from the overlying litter. Comparisons of the results from paired aspen and conifer samples are shown in fig. 9. On reference

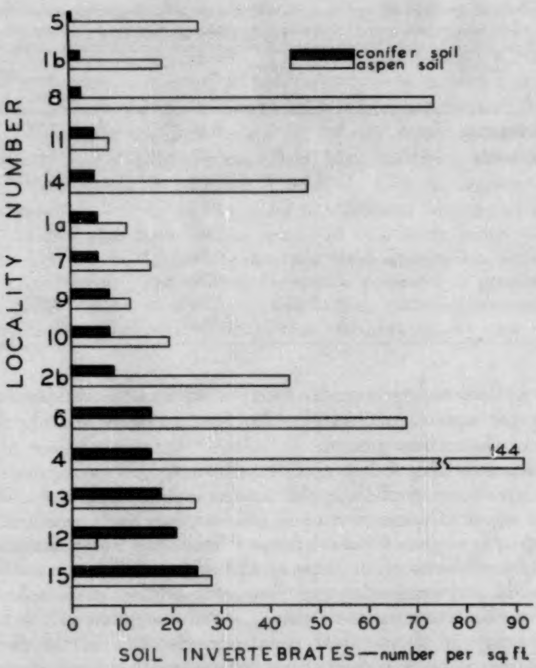

Fig. 9.—Chart showing the number of soil invertebrates per square foot in the paired samples from aspens and conifers

to the figure, it is apparent that the soil macroinvertebrates are in much greater density in the areas dominated by aspens than in areas dominated by conifers, this in spite of the deep litter that exists under the coniferous trees. When one considers the greater organic matter content and the greater moisture content of the soil, as well as the nature of the decomposing plant debris, one must admit that these factors are undoubtedly responsible in a large degree for the greater population density of macroinvertebrates in the aspen soil and litter. Due to the randomness of the sampling, it has not been feasible to attempt a statistical expression of the correlation between soil population densities and the various soil factors.

A summary breakdown into the major groups of soil invertebrates has been attempted in table 4. A few groups of minor importance have been omitted from the table, but there are included all groups which have a high population density and which probably exert considerable influence in the community. For many of the soil groups, detailed discussions are given under the various headings below. In using table 4, it should be kept in mind that the lack of occurrence of a group in the collections does not necessarily mean that the group is absent since the samplings were somewhat small. The number

TABLE 4.—Major groups of soil macroinvertebrates showing the number of localities in which each was taken and the average population density based on all samplings

Group	Aspens		Conifers	
	no. loc.	ind./ft^2	no. loc.	ind./ft^2
Enchytraeid annelids	9	3.21	4	0.48
Lumbricid annelids	3	1.42	2	0.22
Snails	11	2.12	3	0.11
Spiders	12	2.33	11	0.63
Centipedes	7	0.67	3	0.15
Millipedes	3	0.33	–	—
Insect larvae	12	3.79	10	1.15
Beetles	10	1.79	8	1.52
Ants	14	10.79	13	3.59

of localities where each group was taken as well as the density expressed in individuals per square foot indicate, at least to some extent, the relative abundance of the various groups.

By reference to table 4, it is apparent that most groups are more numerous in the aspen community than in the conifer communities, and, indeed, some groups that are abundant in the aspen soil and litter are virtually absent from the soil and litter of the coniferous forest. Snails and millipedes, for example, are typically inhabitants of the aspen soil, being scarce in the coniferous soil, while annelids and centipedes are more often found in samples from the aspens but do occur among the conifers. With exception of the beetles that appear to occur in about equal population densities in the two habitats, groups that are common to both types of communities have a much greater population density in the aspen soil than in the coniferous soil. Thus insect larvae, ants, and spiders have three or more times greater population density in the aspen soil as in the coniferous soil in spite of the fact that the groups are found in nearly equal numbers of localities in the two habitats. Detailed discussions of several groups are given below.

Oligochaeta.—Both the Enchytraeidae and the Lumbricidae are much more numerous in the aspen than in the coniferous soils. While the Enchytraeidae were not identified, the Lumbricidae were determined by Dr. David Causey.

With respect to the enchytraeid annelids, specimens were taken from aspen soil in localities 1, 2, 4, 5, 6, 7, 8, 13, and 14, while this group was represented in the coniferous soil only at localities 2, 4, 6, and 13. In instances where the worms were found in both types of communities, the population density was much greater in the aspens. The greatest population density found in any sample from aspen soil was 56 worms per square foot, while the greatest density in the coniferous soil was five worms per square foot.

Regarding the lumbricid annelids, only two species were collected. One species, *Allolobophora chloroticus* (Savigny), was found only once when two specimens were taken from rich, well-sodded soil of a more or less mature aspen grove at locality 6 near Fish Creek Camp Ground. Smith

(1917) previously reported this form as occurring in Colorado. The other species, *Allolobophora caliginosa* (Savigny) forma *typica*, was found in locality 6 and also in localities 2a, 2b, and 4. Locality 2 and locality 4 are in Rist Canyon. As in locality 6, the soil of the aspen groves in localities 2 and 4 is deep, moist, dark in color, and there is a heavy sod formed largely of grass roots. While the earthworms are by far the more numerous in the aspen soil, a very few specimens were taken from bordering coniferous soils close to the aspen groves in localities 4 and 6. One earthworm was seen in the aspen grove of locality 14 but none were secured in the soil sampling. In spite of the fact that both species found in this study occur with widespread distribution in the United States, the local distribution appears very spotty and it is surprising not to find the worms present in a greater number of localities. The nature of the local distribution perhaps substantiates the statement made by Cockerell (1927) that earthworms are not native to Colorado.

Gastropoda.—Numerous snails were found in aspen groves, but only two species, *Oreohelix strigosa depressa* (Cockerell) and *Zonitoides arboreus* (Say), were found in coniferous areas. *Oreohelix s. depressa* was found at locality 14 in a juniper community and at locality 15 in a yellow pine community where there were a few junipers. Records of this snail from the first mentioned locality are based on dead shells which, due to topography, might have been washed in from a yellow pine area but not from the neighboring aspen area. The single other record of a snail from a conifer area is *Zonitoides arboreus* (Say) taken from locality 5 in an open lodgepole pine stand. In table 5 are listed the snails collected from aspen groves and the localities in which each was taken. From the data secured during this study, it is very evident that there are a great many more snails in the aspen groves than in the neighboring coniferous forest. Snail determinations were made by Dr. J. P. E. Morrison.

Araneae.—Spiders are fairly common in both the coniferous and aspen litter and soil, although the population density is much greater among the aspens. As might be expected, many of the individuals are immature and cannot be determined to species. Seventeen kinds of spiders (some determined only to genus) were found in aspen groves only, less than one-half as many

TABLE 5.—Occurrence of snails in aspen groves

Species	Localities
Discus cronkhitei (Newcomb)	4, 7, 14
Succinea avara Say	4, 6, 13
Vallonia cyclophorella Sterki	1, 4, 8, 14
Cionella lubrica (Müller)	4
Zonitoides arboreus (Say)	1, 5, 8, 14, 15
Euconulus fulvus (Müller)	5
Retinella binneyana pellucida (Lehnert)	8
Oreohelix subrudis (Reeve)	9, 10, 11
Pupilla blandi Morse	14, 15
Vitrina alaskana Dall	14

TABLE 6.—Occurrence of spiders by localities

Spiders	Localities	
	aspens	conifers
Ceraticelus crassiceps Chamb. & Ivie	4	
Ceratinella sp. (subadult)	14	
Clubiona johnsoni Gertsch	4, 7	
Dictyna sp. (immature)	4	
Drassyllus sp. (immature)		7
Euryopis argentea Emerton	1, 2	
Evarcha hoyi Peckham	4, 10	
Floricomus plumalis Crosby	4	
Grammonota gigas Banks	4	
Haplodrassus sp. (immature)		10
Linyphiidae (unidentified juvenile)		4
Lycosa orophila Chamb. & Gertsch	6	
Meioneta tumoa Chamb. & Ivie	1, 13	
Micaria montana Emerton	10	2
Micaria sp. (immature)		10, 11
Microneta febra Keyserling	5	
Microneta viaria Blackwall	2	
Oreonetides sp.	10	
Pardosa sp. (immature)		10, 15
Phrurotimpus sp. (immature)		4
Pelecopsis moestus Banks	4	
Pocadicnemis pumila Blackwall		6
Sisicus penifusiferus Bishop & Crosby	2	
Tetragnatha sp. (juvenile)	15	
Titanoeca sp. (juvenile)	15	
Zelotes sp. (juvenile)	4	9

only in the conifer communities, and two species were found in the soil and litter under both aspens and conifers. The few localities at which any single species was found indicate that the population density for individual species may be small and also that in all probability only a small number of the actually present species were found by the sampling method used during this study. The various kinds of spiders collected along with their localities will be found in table 6. Determinations are by Dr. Willis J. Gertsch.

Formicidae.—Like many of the other groups studied, the ants occur in a greater number of collections, in a greater number of species, and with a greater population density in the aspen groves than in the adjacent coniferous forests. Of 16 species of ants collected, 14 were from the aspen areas and 11 from the conifer areas. Nine species were found in both habitats, five only in the aspens, and two only in the conifers. A summary of the collections of ants is given in table 7. From this table, it appears that some species of ants are much more commonly found in the aspens and some much more commonly found in the conifers. The subspecies of *Leptothorax acervorum*, for instance,

TABLE 7.—Occurrence by localities of ants in aspen and conifer communities

Species	Localities	
	aspens	conifers
Camponotus herculeanus whymperi Forel	7, 10	
Formica cinerea neocinerea Wheeler		9
Formica fusca gelida Wheeler	15	
Formica f. neorufibarbis Emery	15	
Formica f. subsericea Say	8, 9	2, 4, 6, 7, 10
Formica sanguinea subnuda Emery	7	10
Lasius niger neoniger Emery	1	4, 6, 8, 14
Lasius n. sitkaensis Pergande	4, 10	
Leptothorax acervorum canadensis Prov.	5, 6, 7, 9, 10, 12	6, 11
Leptothorax a. yankee Emery	1, 5, 7, 8, 10	14, 15
Myrmica lobicornis fracticornis Emery	2, 4, 5, 6, 10	5, 10
Myrmica sabuleti americana Weber	1, 15	
Myrmica s. hamulata Weber	8	4
Myrmica s. nearctica Weber	4, 6, 9, 11	7, 12, 15
Solenopsis molesta castanea Wheeler		14
Tapinoma sessile (Say)	4, 7, 9	2, 4

are found more often in the aspens as also in *Myrmica lobicornis fracticornis*. On the other hand, *Formica fusca subsericea* and *Lasius niger neoniger* are much more common in the coniferous areas. It is probable that when our data show a particular species confined to one type of community, this may be the result of inadequate collecting and that, with more extensive sampling, the species might be found in both types of communities. The determinations in this group were made by Dr. Robert E. Gregg.

Coleoptera.—The small number of adult beetles collected and the difficulties associated with species determination preclude a detailed discussion. Only two species, the curculionid *Brachyrhinus ovatus* (L.) and the carabid *Metabletus americanus* Dej., were found in any considerable number of localities. In each instance, distribution is in both the coniferous and aspen soil and litter. The former species was collected in localities 4, 6, 11, and 15, while *M. americanus* was taken in localities 4, 6, 7, and 9. Chrysomelid beetles were found in both aspen and conifer areas but only two, *Oedionychis villascens* Lec. and *Anoplitis inaequalis* (Web.), were identified to species. These were from aspen litter in locality 4. Besides *Metabletus americanus*, Dr. William Stehr identified the following ground beetles: *Stenolophus conjunctus* (Say) from pine litter and from aspen soil in locality 4, *Notiophilus semistriatus* Say in pine litter of locality 7, *Bothriopterus saxatilis* Casey from aspen soil and litter in localities 2 and 4, *Selenophorus* (*Selenophorus*) *planipennis* Lec. from pine soil in locality 4, and *Amara cuprealata* Putz. from aspen soil in locality 4.

Of the larval beetles collected, those of the Elateridae are more numerous than those of any other family, being found in both aspen and coniferous communities, but more abundantly in the former. In all, larvae of seven

beetle families were found during this study but many other families would no doubt be found with more intensive collecting. The writer is indebted to Dr. Milton W. Sanderson for assistance in securing determinations of the beetles.

Other insect groups.—Several other groups of insects were found in soil and litter during the present study. The impossibility of securing species determinations in some of the little known groups (as well as in the millipedes and centipedes) of insects and the sparse occurrence of some better known forms preclude a detailed discussion at this time.

Among the Hemiptera, the aphid *Macrosiphum pisi* (Kltb.) was determined from aspen litter and soil in localities 4 and 6, the determination being made by Dr. Louise M. Russell. Dr. R. I. Sailer determined the mirid *Lygus shulli* Knight and the tingid *Corythucha mollicula* O. and D. from aspen litter in locality 5.

With respect to the Diptera, the most commonly represented is the genus *Sciara* of the dark-winged fungus gnats *Sciaridae,* these being identified by Dr. Maurice T. James in collections chiefly, but not always, from aspen soil and litter in localities 1, 2, 5, 7, 9, 11, and 14. Dr. James also identified the heleomyzid *Pseudoleria pectinata* (Lw.) from the aspen community at locality 4 and the bibionid *Philia tibialis* (Lw.) from the aspen litter at locality 8. Numerous other small flies were taken in the samplings, but they belong to groups in which identifications are at present not available.

CONCLUSIONS

A study is made of the differences in microclimate, soil, and fauna of aspen groves and adjacent coniferous forests in Medicine Bow National Forest, Albany Co., Wyoming, and Roosevelt National Forest, Larimer Co., Colorado. Field work was conducted during the spring and summer of 1947.

The general method followed was to compare aspen and bordering conifer communities in 15 localities, the two contrasting communities of each pair being selected for continuity of parent soil material and topography.

Brief descriptions are given of the gross appearance of aspen groves and bordering climax and subclimax conifer communities.

The aspen groves investigated include young to mature stands of aspens (*Populus tremuloides* var. *aurea* (Tides.) Daniels). Beneath the trees may be found in most groves a considerable number of forbs and grasses, with frequently the formation of a heavy sod. A thick litter is not often formed. Such plants as kinnikinnick (*Arctostaphylos uva-ursi* (L.)) and ground juniper (*Juniperus communis* var. *montana* Ait.) are often conspicuous.

The coniferous forest of the areas studied are either climax or subclimax. The climax forests are of yellow pine (*Pinus ponderosa* Doug.) at lower elevations or are of a mixture of spruce and fir (chiefly *Picea engelmanni* (Parry) Engelm. and *Pseudotsuga taxifolia* (Lamb.) Brit.) at higher elevations. The subclimax coniferous forest is composed of lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.). Under the trees of the coniferous communities, either climax or subclimax, the needle layer is often two or three inches thick and there is a minimum of forbs and grasses.

No consistent differences were found between the two types of communities with respect to relative humidity, air temperature, or light intensity during the growing season. These microclimatic factors appear to be related to topography rather than to the nature of the dominant plants.

At lower elevations where the yellow pines occur in somewhat open stand, there is a higher evaporation rate among the pines than among the aspens, but at higher elevations where the conifers form a dense stand and the aspens grow in more open stand, the evaporation rate in the aspens exceeds that in the conifers.

The soil of the aspen groves is less rocky than that of the conifer communities, but there is no definite difference in the soil texture in the two communities. In general, the soil is a sandy loam derived from igneous and metamorphic rocks.

The soil of aspen groves is consistently more alkaline and contains more moisture and organic carbon than the soils of the coniferous stands. These differences are no doubt the result of the reactions of the dominant plants.

It was impossible to discern any differences or modifications in the soil temperatures of the two communities.

Samplings of soil microinvertebrates (defined as small organisms that cannot be conveniently collected by sifting) were made by use of Berlese funnels. The microinvertebrate populations in the aspens and in the coniferous forest appear to be about the same in density. Pseudoscorpions occur in the aspens but not in the coniferous litter, while Collembola of the suborder Symphypleona were taken only in the conifer litter and soil.

By sifting one square foot samples of soil and litter, both qualitative and quantitative collections were made of the macroinvertebrates of the soil and litter. Most groups of the invertebrates, except the Coleoptera, occur in greater population density in the aspens than in the conifers. Snails, earthworms, and millipedes occur in relatively small numbers in the conifer soil and litter.

Two species of earthworms were collected. These are confined chiefly to the sod of fairly mature aspen groves.

Two species of snails were taken from beneath conifers, while ten species of snails were collected in aspen groves.

More than twice as many kinds of spiders were found in the aspen as in the conifer soil and litter and the population density was over three times greater in the aspens than in the conifers.

A greater population density and a slightly greater number of species of ants are found in the aspen than are found in the coniferous soil and litter.

Adult beetles appear to range in both aspen and conifer communities in about the same population density. As for the larvae, those of the Elateridae are the most common.

Among the Diptera collected, the dark-winged fungus gnats of the genus *Sciara* are common from aspen soil and litter although they also occur to some extent among the conifers.

Based on this study, it would appear that the presence of dominant broadleafed deciduous trees as the aspen, along with associated vegetation, exerts considerable modifying influence upon the soil of the aspen groves, being

probably the factor largely responsible for differences in the nature of the soil between aspen and conifer communities. It is obvious that the nature of the soil in the aspen groves is responsible to a large extent for a greater population density of soil invertebrates, probably through the establishment of more favorable conditions of moisture and food.

The present investigation substantiates the statement of Lutz and Chandler (1946) that *Populus tremuloides* is a "soil improving" species of tree.

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The Morphology and Relationships of Sigillarian Fructifications From the Lower Pennsylvanian of Indiana

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During the field season of 1953, a large number of compressions of a single cone type were found in a relatively restricted horizon of the lower Pennsylvanian period in a limited area in Warren County, Indiana. These strobili were not comparable morphologically to any of the several previously described genera of fossil cones from Indiana. This fact, coupled with the discovery of megaspores *in situ* in these exceptionally well-preserved fructifications prompted this investigation. Because of the wealth of sigillarian foliage and trunk impressions in the surrounding matrix it was suspected that these cones were members of the relatively rare genus *Sigillariostrobus*. However, cones similar to the cones mentioned here had been placed by Lesquereux in his genus *Lepidocystis*. David White in restudying the same material concluded that Lesquereux had erred and assigned the cones to the genus *Sigillariostrobus*.

The significance of the problem lies in the fact that although thirty-five species of the genus *Sigillariostrobus* have been described since 1870, very little is known about the morphology of these fructifications. In addition, the palynological literature is rich in artificial spore form genera, whose botanical relationships are unknown. Therefore, the proof of the relationship of megaspores and microspores, which have already been described, to known fructifications would be another step toward the unification of the presently unwieldly and complex paleobotanical and palynological systems of nomenclature.

Acknowledgments.—The author wishes to express his appreciation to Dr. James E. Canright for guidance during the course of this research. A research grant from the Indiana Academy of Science permitted the author to examine fossilized cone materials in the U. S. National Museum, Washington, D. C. Dr. R. V. Melville of the Geological Survey and Museum, London, England, kindly loaned slides of spore materials from the Kidston Collection. The author benefited from conferences with Dr. Sergius H. Mamay of the U. S. Geological Survey, Washington, D. C., Mr. Harold Hutchison, and Mr. G. K. Guennel of the Indiana Geological Survey, and thanks are extended to them.

Horizon (s)

The majority of the cone material described in this paper was found in the SW1/4 SW1/4 sec. 35, T. 20 N., R. 9 W., Warren County, Indiana (Fig. 1) on the property of the Interstate Sand and Gravel Company.

The fossils under consideration were found in a thirteen inch siltstone and ironstone ($FeCO_3$) zone approximately 23 inches above a coal seam which measured 8 inches in thickness. This coal rested upon, and was underlain by soft clay. The horizon in which the fossils were found was about 7 inches below the base of glacial till.

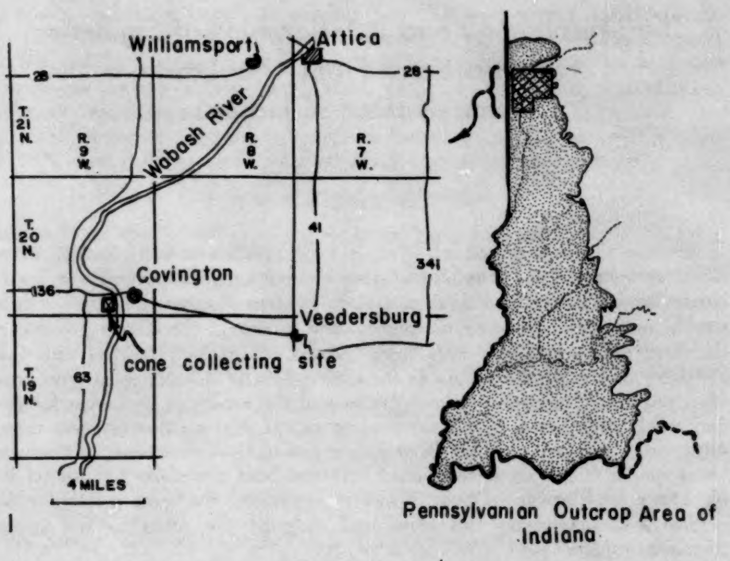


Fig. 1.—The area from which the cones were collected is blocked out on the map of the Pennsylvanian outcrop area of Indiana at the right. A detail map of the area is shown to the left.

Minshall limestone, which lies above the Minshall coal, outcrops to the north of the area described, along the bank of the Wabash river. The strike of the strata is north-northwest to south-southeast, while the regional dip is approximately 20 feet per mile to the southwest. Therefore, with the nearness of the outcrops of Minshall limestone to the fossil site, and the regional dip of the strata, the base of the Minshall limestone, if it were now present at this site, would not be a great distance above the horizon from which the cones were taken.

Further evidence of the age of the strata is supplied by Wier (1951) who listed the coal mined from the Abernathy and Stout slope mine in sec. 1, T. 18 N., R. 9 W., as Minshall coal.

The fact that the area in question is a bed rock island surrounded on the east by the present bed of the Wabash river and on the west by glacial outwash which filled a previously existing river bed makes correlation of the out-crops with surrounding strata difficult. Nevertheless, the fact that Minshall limestone outcrops to the north of the fossil site, and Minshall coal was mined a short distance to the south of the area supports the assumption that the stratum from which the cones were taken belongs either in the middle or the lower part of the Brazil formation.

Cones comparable to those discussed in this paper have also been found by the author in ironstone concretions associated with Lower Block coal in

Greene and Martin Counties, Indiana. These cones are thus identified as having come from the lowermost part of the Brazil formation.

Therefore, these three areas in Indiana from which comparable cone materials have been removed fall within the Brazil formation which correlates with the upper one-quarter of the Pottsville series. This being the case, the vertical distribution of these cones appears to be approximately 75 to 90 feet.

MATERIALS AND METHODS

In all, cone fragments representing 67 strobili were collected. The longest fragment measured 16 cm; the average width of the fragments was 11.6 mm. No complete cones were found, *nor were any peduncles uncovered*. The majority of the compressions are apparently middle portions of the cones and only a few pieces are regarded as distal portions.

Where possible the cones were taken apart in order to determine the relative positions of the components. After study, these parts were attached to cards bearing the slab numbers from which the part was taken. To prevent further contamination or breakage of the cone parts and megaspores, discs were cut out to fit petri dishes. Tongues were cut in these discs to accomodate the labels bearing the cone parts and megaspores.

Some of the specimens were cleared of carbonaceous material by the use of a chisel-edged dissecting needle. In one instance the axis of the cone was removed for examination.

Materials resembling microspores were obtained from a portion of a sporophyll which was macerated in Schulze's reagent and then neutralized in ten percent aqueous KOH. These spores were then stained with safranin in alcohol. After staining, the spores were dehydrated in an alcohol series and mounted in diaphane.

Slides of spore materials taken from specimens of *Sigillariostrobus quadrangularis* (Lx.) White in the Kidston Collection in the Geological Survey and Museum, London, England were made available for the author's study.

Specimens of *Sigillariostrobus* and *Lepidocystis* in the collections of the United States National Museum and the United States Geological Survey in Washington, D. C. were also examined.

MORPHOLOGY OF THE SIGILLARIOSTROBUS COMPRESSIONS

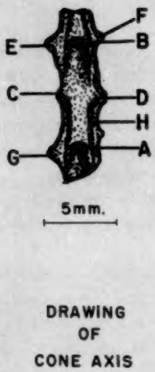
Along with the cone materials, leaf impressions and compressions (*Sigillariophyllum* ?) were by far the most common, not to mention the myriad megaspores found both *in situ* in the cone material and scattered throughout the surrounding matrices. Although, as previously mentioned, some portions of trunk casts and compressions were found, none bore marks which could be identified as cone scars.

Associated with the above-mentioned fossilized plant materials were some well-preserved compressions of fern-like foliage, which were identified as *Dactylotheca aspera* Brong.

Careful examination of the slabs containing plant materials were made at the site of the collection and later in the laboratory, but in no case were sigillarian leaves found attached to brances or other structures. Likewise, none

of the cone fragments was attached to any plant organ as found. Therefore, this description concerns only the morphology of the cone fragments, the megaspores associated with the strobili, and the microspores freed from the compressed cones.

Although the sigillarian cones, which have been figured by several authors,



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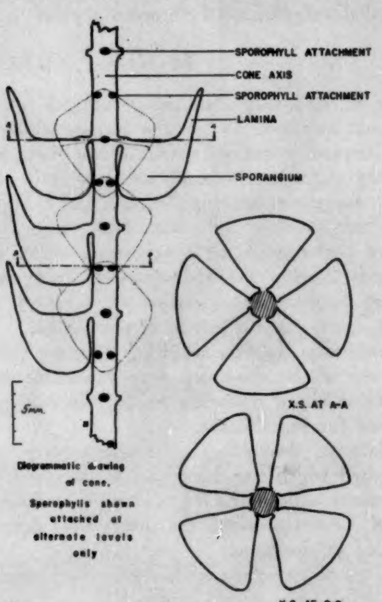

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Figs. 2-4.—*Sigillariostrobus quadrangularis* (Lx.) White. 2. Drawing of the cone axis; 3. Diagrammatic drawing showing arrangement of the sporophylls on the axis; 4. Drawing of a sporophyll.

have been shown to have been attached to an elongate, thin peduncle, none of the many specimens from this site was found to be pedunculate. Bochenski (1939) states that this peduncle was of insufficient diameter to have borne the fructifications in an erect manner as they appeared in among the uppermost foliage on the trunk so that the strobili, by their own weight, hung pendant. However, it is significant that no fossilized remains were found in the Indiana material, even among the scattered fragments, which would suggest the presence of such a supporting structure.

Although separate sporophylls were encountered in this Warren County material, not one cone fragment was found wherein any region of the cone axis was devoid of sporophylls. The fructifications that have been found from this site all bear sporophylls which are closely appressed to the cone axis.

One axis was dissected out of the cone (fig. 2). The axis is compressed and is 1 mm thick, 11.5 mm long, 4 mm wide as measured from point E to F, and 2.25 mm wide at point H. Points A, B, E, F, and G appear to be sporophyll attachment points. The points A and B appear to depart from the axis at nearly a right angle. The reverse of the axis is essentially the same as the face discussed. The attachment points at the levels EBF and GA suggest that the sporophylls in this specimen were arranged on the axis in verticils or whorls (fig. 3). It is the author's opinion that the attachment points at level CD were not preserved, but that they should have been so aligned that the sporophylls of alternate whorls would be in vertical alignment (fig. 3).

One sporophyll (fig. 4) was removed relatively intact from the remainder of a cone fragment. This sporophyll measures 9 mm from the base of the keel subtending the sporangium to the apex of the lamina. The lamina extends 4 mm above the top of the sporangium. The distance from the adaxial surface of the sporangium to a vertical line dropped from the apex of the lamina is 7 mm. The sporangium measures 4 mm from the distal to proximal ends, and is 5 mm high. The abaxial face of the sporophyll is roughly rhomboidal in shape, 9 mm high and 8 mm wide at the widest point. A midrib traverses the length of the upper surface of the sporangium and continues up the abaxial face of the lamina terminating in a flattened area (fig. 4). The sporangium occupies the lower 5 mm of the sporophyll, is triangular to rhomboidal in cross section, and is 4 mm wide at the widest point. The attachment point of the sporophyll appears to be at the top of the sporangium in line with the midrib. This places the attachment point (fig. 4) 5 mm below the tip of the lamina. Attachment points A and B of the axis are 7.5 mm apart. Thus, the tip of the lamina of the sporophyll attached at point A could lie against the base of the sporophyll attached at the point B leaving a 2 mm overlap. Thus arranged, the top of the sporangium of the lower sporophyll would be 2 mm below the base of the sporangium of the sporophyll attached above it at point B. (see fig. 3)

DISCUSSION OF CONES AND SPORES

Schimper's (1870) description of the genus *Sigillariostrobus* is applicable to any cone which is pedunculate, elongate, bearing microsporangia and

megasporangia adaxially. Bochenski (1939) has pointed out the fact that the cones were probably pendant, and that after they ripened they fell apart. He further states that these reasons would account for the fact that the discovery of such cones attached to the trunk is rare.

Schopf (1941) has pointed out that a primary difference between the genera *Lepidostrobus* and *Sigillariostrobus* is that the latter fructification was borne on a peduncle or stalk while the former was borne on an ordinary leafy shoot. He further states that information relative to the Lower Carboniferous sigillarian fructifications is extremely scanty. He then states (p. 26): "It would be expected that at some time in the early history of the groups, specialized cone-bearing peduncles would be less in evidence."

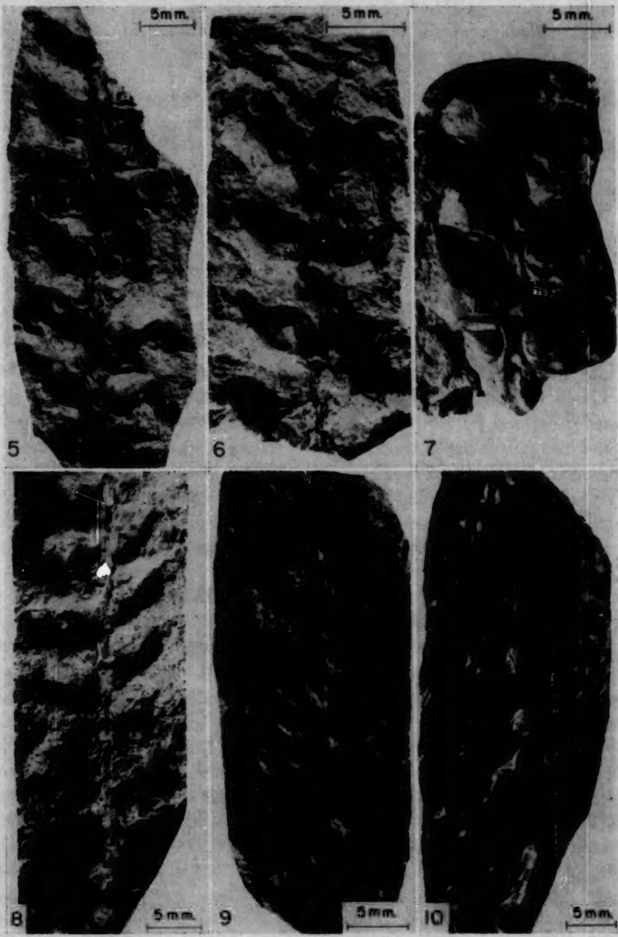
None of the cones from Indiana was complete, and there is the possibility that these fragments can be accounted for by Bochenski's suggestion that they fell apart after they ripened. However, the lack of peduncles either attached to or separated from the cones in the matrix does not rule out the possibility that such structures did exist as the subtending and supporting organ for these Indiana specimens. These cones may have become detached from the peduncle before that structure was released so that the cones were deposited separately, and perhaps at quite a distance from the place where they were produced. It is also possible, if the latter conditions obtained, that the transporting agency may have been severe enough to have wrested the already fragile cone fragment from the supporting structure. Following the separation, the heavier cone may have dropped out to be covered by the silt and mud while the lighter peduncle was carried on to a distant site. In many present-day forms there is an abscission layer between the fruit and its supporting structure which facilitates the separation of the fruit from the supporting organ. This could have been the case with the peduncles of these sigillarian fructifications. However, no such discovery of separately preserved peduncles or peduncles attached to trunks has been made to date.

The presence of sigillarian leaves in and around the cones in the surrounding matrix attests to the fact that relatively fragile structures were preserved. This, then, leaves the problem of the presence or absence of the peduncles of these cones as they occurred in their original state an unanswered question in regard to this Indiana material.

Bochenski (1939) discussed the dropping of the sporophylls from the cone axis and is of the opinion that they fell off from the distal toward the proximal end. The sporophylls dropped from the axis leaving the denuded upper portion, while the lower section remained intact. If this condition existed, then the upper or distal ends of the cones in complete specimens would be represented by the denuded axis while the lower areas, with the progressively younger and less mature sporophylls would show a graded series from open to closely appressed sporophylls.

Cones with denuded upper portions of axes have not been found in this Indiana material. Here, if we follow Bochenski's thesis, the condition of the fossilized cones would suggest that the portions of the strobili from Indiana are all immature, and that none of the mature and denuded portions of the axes have been included. Bochenski's supposition is not supported by the Indiana material.

Megaspores were found *in situ* in several of the cones from the Warren County, Indiana material. These megaspores have been identified as *Triletes glabratus* Zerndt. The two megaspores pictured in figs. 14 and 15 were taken from the matrix immediately surrounding a cone fragment. These spores, which have the same size and general morphology as the megaspores found *in situ*, were selected for photographing because of their excellent state of



Figs. 5-10.—*Sigillariostrobus quadrangularis* (Lx.) White. 5-8. Specimens from Warren County, Indiana. 9-10. Specimens in Lacoe Collection. Collected in Port Griffith, Pa. 9. USNM No. 25274; 10. USNM No. 25277.

preservation. Furthermore, abortive megaspores, which were discussed by Bochenski, were not found in this material.

The concept of a curved cone is not verifiable by this Indiana material because of the relatively short size of the fragments which have been found.

A comparative study of the Indiana material with that deposited in the Lacoe Collection in the United States National Museum indicates that the Indiana fructifications (figs. 5-8) are the same as those identified as *Sigillariostrobus quadrangularis* (Lx.) White (figs. 9 and 10). The widths of the two groups of cones agree (10-12 mm), as does the general morphology. The cone specimens in the Lacoe Collection likewise consist of short fragments. However, the most important fact is that the cones identified by David White as *Sigillariostrobus quadrangularis* (Lx.) also lack peduncles. The amount of matrix surrounding the specimens in the Lacoe Collection is small, however, had such supporting structures been found they probably would have been recognized and retained.

An examination of the material in the National Museum gives the impression that Lesquereux, after studying the material that came to him, set up the genus *Lepidocystis* to cover those fructifications which looked like sigillarian cones but which lacked the peduncles. The taxonomy of the group is confused by the assignment by Lesquereux of separate sporangia as well as cones to the genus *Lepidocystis*.

White (1903) examined the specimens of *Lepidocystis quadrangularis* Lx. in the Lacoe Collection and recorded his conclusion as follows: "In structure the cones described by Lesquereux (Coal Flora, Vol. II, p. 455) as *Lepidocystis quadrangularis* seem to correspond to the strobili of Sigillariae."

Jongmans (1930) in reviewing the literature concerning these cone materials, made the following terse and cautious comment: "White vergleicht mit *Sigillariostrobus*. Diese Art und *L. pectinatus* sehen nach einem Strobilis aus. Ich kann jedoch nicht entscheiden ob es sich um *Sigillaria* oder *Lepidodendron* gehandelt hat."

A further complication arises when one considers the arrangement of the sporophylls on the axis. Bochenski (1939) listed the opinions of various authors and stated that the predominant conviction was that the sporophylls of sigillarian cones were arranged in whorls around the axis. After examining his own material, Bochenski (1939) concluded that Zeiller (1884, 1886), Hirmer (1927), Bode (1928), and Bochenski (1936), among others, had erred and that the sporophylls were spirally arranged. Schopf (1941) in reviewing the literature did not mention the 1939 paper by Bochenski, but stated that there is probably a greater tendency toward verticillate arrangement of sporophylls in species of *Sigillariostrobus* than in species of *Lepidostrobus*. Because Zeiller (1911) and Binney (1871) reported whorled arrangement of sporophylls in species of *Lepidostrobus*, Schopf stated that this character could not be considered diagnostic, and, further, that it appeared to have been over-emphasized. Arnold (1947) in discussing the sigillarian fructifications stated that the axis bears whorled or spirally arranged sporophylls.

The latest word has been added by Felix (1954) who states that the sporophyll arrangement of the lepidostrobi has lost significance as an important character. The author agrees wholeheartedly with this statement.

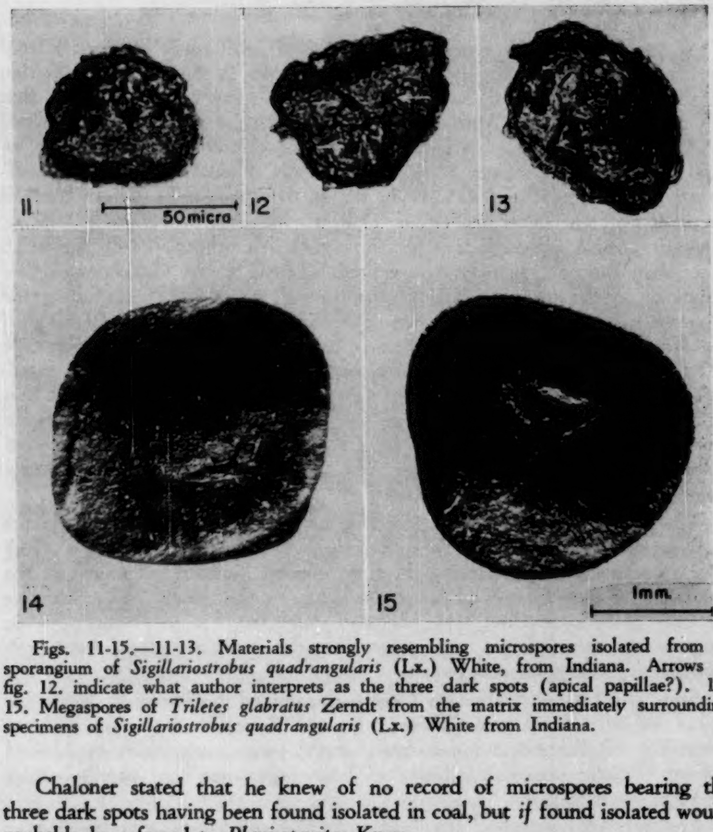
DESCRIPTION OF SPORES

A further aid in the generic identification of fossil cones has been offered by Chaloner (1953), who, after studying specimens in the Kidston Collection of the British Geological Survey and Museum, states that he believes that the megaspores of the Mazospora section, which he proposes (exemplified by *Triletes mamillarius* Bartlett and *Triletes glabratus* Zerndt), were of sigillarian origin. Chaloner (1953) justifies his subdivision of the Aphanozonati defined by Schopf (1938) in the following way: "I believe that all the spores of the latter section of *Triletes* (Mazospora, *sect.nov.*) were of Sigillarian origin, although it is not impossible that other types of Sigillarian cones than *Mazocarpon* may have existed; whereas, so far as I know, spores belonging to the former group (Aphanozonati, *sensu stricto,* excluding the Mazospora section) have never been recognized from cones reliably assigned to *Sigillariostrobus* and can clearly never have come from a Mazocarpon type of sporangium." Felix (1954) states that megaspores from sigillarian fructifications have been placed in the Aphanozonati section of *Triletes,* but that *T. glabratus* and *T. mamillarius* are the only two attributable to sigillarian cones. He further states that neither of these two species are known to occur in *Lepidostrobus.* Thus, it seems that these two species of *Triletes* are diagnostic criteria of sigillarian cones.

The discovery of megaspores identified as *Triletes glabratus* Zerndt in the Indiana material which resembles the *Sigillariostrobus quadrangularis* (Lx) White specimens in the Lacoe Collection supports White's assignment of the specimens of *Lepidocystis quadrangularis* Lx. to the genus *Sigillariostrobus* for two obvious reasons: (1) the two cone samples are comparable in morphology; and (2) the megaspores from the Indiana material have been shown to be of sigillarian origin.

From the Kidston Collection Chaloner examined specimens of *Sigillariostrobus* collected by David White from the Briceville formation (Upper Pottsville) of Tennessee, and isolated several megaspores which he labelled "affinity *Triletes mamillarius* Bart." These megaspores bore papillae which are six micra in height.

Chaloner also examined specimens of *Sigillariostrobus rhombibracteatus* Kidston and found microspores in them which he described in the emended diagnosis of the cone in the following manner (1953): "Microspores circular to triangular, thin-walled, 25-70 micra in diameter, typically about 55 micra. Three dark spots present near to the spore apex, in the inter-radial positions. Tri-radiate sutures sometimes developed: tri-radiate ridges or other surface decorations absent." Schopf (1941) pictured the microspores of *Mazocarpon oedipternum.* As pointed out by Chaloner, the similarity of the microspores found by Schopf in *Mazocarpon oedipternum,* and those which he found in *Sigillariostrobus rhomibracteatus* is striking. Furthermore, in peels from one specimen of *Sigillariostrobus quadrangularis* (Lx.) White in the Kidston Collection (slides 6146 d-f), Chaloner isolated more microspores which resemble those which he found in *S. rhombibracteatus.* Therefore, it appears that the microspores from the aforementioned cones can be used as a diagnostic characteristic for the identification of sigillarian cones.



Figs. 11-15.—11-13. Materials strongly resembling microspores isolated from a sporangium of *Sigillariostrobus quadrangularis* (Lx.) White, from Indiana. Arrows in fig. 12. indicate what author interprets as the three dark spots (apical papillae?). 14-15. Megaspores of *Triletes glabratus* Zerndt from the matrix immediately surrounding specimens of *Sigillariostrobus quadrangularis* (Lx.) White from Indiana.

Chaloner stated that he knew of no record of microspores bearing the three dark spots having been found isolated in coal, but *if* found isolated would probably be referred to *Plani-sporites* Knox.

Material suggesting the presence of microspores was found in the Indiana material (figs. 11-13). The material is not in a good state of preservation, however, these objects, which are spore-like in appearance, did not bear as distinct a group of three dark spots (apical papillae) as does Chaloner's and Schopf's materials, nor were these objects from the Indiana material as circular in outline as the afore-mentioned ones. In spite of this slight dissimilarity, the average size of the material is 55 u, which corresponds with Chaloner's measurements. The specimen pictured in fig. 12 shows the three dark spots, and these resemble those figured by Chaloner (1953, fig. 8 A-D) from spores of *Sigillariostrobus rhombibracteatus*.

Furthermore, Felix (1954) reported the discovery of microspores which he said are plainly *Plani-sporites* Knox and "quite similar to microspores of the same genus reported in *Sigillariostrobus rhombibracteatus* by Chaloner" in a specimen of *Lepidostrobus gallowayi* Arnold. He then stated that the

presence of *Plani-sporites* cannot be regarded as conclusive evidence of sigillarian affinities although Schopf and Chaloner have obtained this spore from their materials.

The fact that there were no megaspores in the one cone fragment from Indiana from which materials resembling microspores were obtained would lend partial support to the idea proposed by Schopf (1941) that the Upper Carboniferous sigillarian cones were probably unisexual, a condition which has been demonstrated by Bochenski (1936) with sigillarian materials.

The specimens which were identified as *Lepidocystis quadrangularis* Lx. and later assigned to *Sigillariostrobus quadrangularis* by White (without diagnosis and based upon superficial evidence) have now been shown to be correctly placed in the Sigillariae.

HISTORY OF SIGILLARIOSTROBUS AND LEPIDOCYSTIS

The first reference to these cones was made by Goldenberg (1855, 1857), who described and figured a number of cones associated with *Sigillaria tessellata* Brong. and *Sigillaria intermedia* Brong., which he assumed to be the trunks to which these fructifications had been attached. In examining this cone material Schimper (1870) concluded that a new genus had been discovered. Therefore, he described the genus *Sigillariostrobus* in the following terms: "*Spicae pedicellatae strobiliformes oblongo- et elongato- cylindricae, bracteis e basi ovato-triangulari subito angustae, lanceolatae, medio-costatae. Sporae sporangio bracteae basis lateri anteriori adfixio (incluso?) inclusae, magnae (macrosporae?) et minores (microsporae?) tetraedae.*"

The above description is general and includes any cone-like fructification which is pedunculate, elongate, and probably bearing megaspores and microspores adaxially on linear-lanceolate or ovate sporophylls. Although Schimper describes the genus he did not designate a type specimen.

The following list refers only to the first publication of each of the species of *Sigillariostrobus* and does not mention the subsequent accounts of discoveries of sigillarian cones which have been assigned to these species.

The genus *Lepidocystis* is treated in a similar manner for the reason that Lesquereux in 1880 placed cone fragments in this genus which are similar to the cones found in Indiana and discussed in this paper.

1870 *Sigillariostrobus* sp. Schimper. Pal. Veg. 2:105, pl. LXVII, figs. 13-24.
1871 *Sigillariaestrobus Cordai* Feistmantel. Sitzungab. K. Böhm. Ges. Wiss., p. 59.
1871 *Sigillariaestrobus Feistmanteli* Feistmantel. *Ibid.*, p. 59.
1873 *Sigillariostrobus bifidus* Geinitz. Neues Jahrb., p. 700, pl. III, figs. 5-7.
1873 *Sigillariaestrobus gracilis* (Carruthers) Feistmantel. Verh. K. K. Geol. Reichanst., p. 83.
1873 *Sigillariostrobus gravidus* Feistmantel. Zeitschr. Deutsch. Geol. Ges. 25:595.
1873 *Sigillariaestrobus Pedroanus* (Carruthers) Feist. Verh. K. K. Reichanst., p. 83.
1876 *Sigillariostrobus Goldenbergi* (Schimper) Feist. Palaeontogr. 23:253.
1877 *Sigillariostrobus fastigiatus* (Goeppert) Grand'Eury. Fl. Carb. Dept. Loire, p. 160.
1877 *Sigillariostrobus mirandus* Grand'Eury. *Ibid.*, p. 160, pl. XIV, fig. 5.
1877 *Sigillariostrobus rugosus* Grand'Eury. *Ibid.*, p. 160, pl. XIV, fig. 4.
1884 *Sigillariostrobus laurencianus* Lesqx. Second Geol. Survey Pa., Report Prog., P (Coal Fl., vol. 30), p. 794.

1884 *Sigillariostrobus nobilis* Zeiller. Ann.. Sci. Nat. (6), Bot. 19:267, pl. XII, fig. 1-2.
1884 *Sigillariostrobus souichi* Zeiller. *Ibid.*, 19:267, pl. XL, figs. 5-5b.
1884 *Sigillariostrobus strictus* Zeiller. *Ibid.*, 19:266, pl. XI, figs. 1-1a.
1886 *Sigillariostrobus Crepini* Zeiller. Bass. Houill. Valenciennes, Atlas, pl. LXXVII, figs. 2, 3; text, 1888, p. 605.
1888 *Sigillariostrobus elongata* (Brong.) Schenk. Schenk, Foss. Pflanzenreste, Breslau, p. 84.
1888 *Sigillariostrobus polypleca* (Boulay) Schenk. *Ibid.*, p. 84.
1888 *Sigillariostrobus scutellata* (Brong.) Schenk. *Ibid.*, p. 84.
1888 *Sigillariostrobus spectabilis* Renault. Bull. Soc. Hist. Nat., Autun. 1:177, pl. III, fig. 1.
1890 *Sigillariostrobus pedicellifolius* Grand'Eury. Grand'Eury, Geol. Paleont. Bass. Houill., Gard. Saint Etiennes, p. 258, pl. XI, fig. 5.
1897 *Sigillariostrobus ciliatus* Kidston. Trans. Roy. Soc. Edinburgh, 39:53, pl. II, figs. 2-9.
1897 *Sigillariostrobus rhombibractiatus* Kidston. *Ibid.*, 39: 50, pl. I, figs. 1-8, pl. II, figs. 10-11.
1898 *Sigillariostrobus ? incertus* D. White. 20th Ann. Rept., U.S.G.S., 1898-99, pt. 2, 1900, p. 867.
1903 *Sigillariostrobus clavatus* (Lesq.) White. Bull. U.S.G.S., no. 211, p. 106.
1906 *Sigillariostrobus major* (Germar) Zeiller. Bass. Houill. Perm. Blanzy., pt. 2, Fl. Foss., Paris, 1906, p. 172, pl. XLV, fig. 1.
1907 *Sigillariostrobus* cf. *Gaudryi* (Renault & Herlter) Schuster. Geogn. Jahresh., Munschen, 1907 (1908), 20:230, pl. X, figs. 7, 8.
1907 *Sigillariostrobus* (?) *lineatus* (Lesq.) C. Unger. Pub. Hist. Soc. (Schuylkill Co.) 2:(1):101.
1907 *Sigillariostrobus piceaeformis* Schuster. Ber. Bay. Bot. Ges. 12(1):53, fig. 16a on unnumbered plate.
1911 *Sigillariostrobus hastatus* White. J. Geol. 19(2):122.
1928 *Sigillariostrobus Gothani* Bode. Jahrb. Preuss. Geol. Landesans. 49:239, text figs. 1-4.
1936 *Sigillariostrobus czarnockii* Bochenski. Ann. de la Soc. Géol. de Pologne, T. XII, pp. 223-230, pl. V, figs. 38-39, pls. VI-VII.
1938 *Sigillariostrobus sphenophylloides* LeClercq. Soc. Géol. Belgique Annales. 61:164, pls. 1-4.

Of the thirty-five validly described species of *Sigillariostrobus*, only seven are known from the United States (Pennsylvania, Kansas, and Texas); the remainder are either from Europe or England. Of this latter group, fourteen have come from France, seven from Germany, one from Poland, three from western Czechoslovakia, and three from England.

In 1880, in the Report of Progress of the Second Geological Survey of Pennsylvania, Leo Lesquereux (p. 454) proposed the new genus *Lepidocystis* in the following manner: "Spore cases long, naked, attached in right angle and opposite to a broad rachis, or short, placed in spiral order upon flexuous axes, or isolated sporanges, detached from the strobiles of unknown character. . ." To this he added: "The limitation of this genus is vague and uncertain."

The following list refers only to the first publication of each of the species of Lepidocystis.

1880 *Lepidocystis* Lesquereux. Second Geol. Surv. Pa., Rept. Prog., P (Coal Flora, vol. 2), p. 454.
1880 *Lepidocystis angularis* Lesq. *Ibid.*, p. 456, pl. LXIX, figs. 16, 17.
1880 *Lepidocystis bullatus* (Lesq.) Lesq. *Ibid.*, p. 458, pl. LXIX, figs. 24, 24a.
1880 *Lepidocystis fraxiniformis* (Goppart & Berger) Lesq. *Ibid.*, p. 457, pl. LXIX, figs. 21-23.

1880 *Lepidocystis lineatus* Lesq. *Ibid.*, p. 454, pl. LXIX, fig. 4.
1880 *Lepidocystis obtusus* Lesq. *Ibid.*, p. 455, pl. LXIX, figs. 6, 7.
1880 *Lepidocystis pectinatus* Lesq. *Ibid.*, p. 454, pl. LXIX, fig. 3.
1880 *Lepidocystis quadrangularis* Lesq. *Ibid.*, p. 455, pl. LXIX, fig. 5.
1880 *Lepidocystis vesicularis* (Lesq.) Lesq. *Ibid.*, p. 457, pl. LXIX, figs. 18-20.
1897 *Lepidocystis brevifolius* (Lesq.) D. White. 19th Ann. Report, U.S.G.S., 1897-98 (1899), p. 461.
1899 *Lepidocystis Jenneyi* D. White. Mon. U.S.G.S., vol. 37, (Fl. Lower Coal Meas. Mo.) p. 215, pl. LX, figs. 1a, 3.
1899 *Lepidocystis missouriensis* D. White. *Ibid.*, p. 216, pl. LXIV, fig. b; pl. LXXIII. fig. 2.
1905 *Lepidocystis inquisitus* D. White. Prof. Papers U.S.G.S., No. 35, p. 75, pl. IV, figs. 12-14.
1905 *Lepidocystis siliqua* (Dawson) D. White. *Ibid.*, p. 74.
1937 *Lepidocystis chesterensis* D. White. U.S.G.S. Prof. Paper 186, B, p. 34, pl. 6, fig. 2.

The above listed species are exclusively American, although specimens of two previously-described species of *Lepidocystis* have been reported from the Coal Measures of South Wales. Most *Lepidocystis* species were collected from the Carboniferous of Pennsylvania, but two species were collected from the Upper Carboniferous of Missouri, one from the Mississippian of Arkansas, and one is reported from the Devonian of Maine.

LEPIDOCYSTIS (Lesquereux) emend.

1880 *Lepidocystis* Lesquereux *in* Description of the coal flora of the Carboniferous formation in Pennsylvania and throughout the United States. Pa. Second Geol. Survey Rept. Progress, P. 2:454, pl. 59, fig. 3.

Lesquereux's original description reads as follows:

Spore cases long, naked, attached in right angle and opposite to a broad rachis, or short, placed in spiral order upon long flexuous axes, or isolated sporanges, detached from strobiles of unknown character.

The emended diagnosis for the genus *Lepidocystis* reads as follows:

Sporangia long or short, attached at right angles and opposite to a broad or narrow axis, or isolated sporangia detached from strobili of Lycopsid affinity.

This emended description leaves the sporangia which are attached to sporophylls in the genus *Lepidostrobophyllum*. It includes cone fragments whose true generic description (*Lepidostrobus* and *Sigillariostrobus*) is indefinable.

SUMMARY

Fossilized fructifications were found in ironstone and siltstone strata in Warren County, Indiana, which did not agree with specific diagnoses of fossil cones previously found in Indiana. The age of the strata from which the cones were taken is probably part of the lower Brazil formation in the Pottsville series of the Pennsylvanian. Morphologically the Indiana materials compare with the specimens of *Sigillariostrobus quadrangularis* (Lx.) White in the Lacoe Collection in the United States National Museum. Megaspores isolated from the Indiana cones have been identified as *Triletes glabratus* Zerndt, a megaspore species identified as of sigillarian origin. Materials strongly resembling microspores from one of the sporangia of the Indiana

cones are similar to those found by Chaloner in specimens of *Sigillariostrobus rhombibracteatus*, and to those found by Schopf in *Mazocarpon oedipternum*.

The fossilized cones are of varying lengths, and apparently none is a complete specimen. In no case was a peduncle found. The cones average 11.6 mm in width. It is the author's interpretation that the sporophylls were arranged in whorls of four, and that each successive whorl was rotated so that the sporophylls of alternate whorls were in vertical alignment.

The discovery of microspores in one cone fragment in which no megaspores were found lends partial support to the concept of others, that the cones may have been unisexual.

The specimens from Indiana, because of their gross morphological similarity to the material identified by White, are also assigned to *Sigillariostrobus quadrangularis* (Lx.) White.

The genus *Lepidocystis* is herein emended to include cone fragments whose true generic description is indefinable, and sporangia which are detached.

The genus *Sigillariostrobus* should be emended when more information relative to the microspores and megaspores of more species have been studied.

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Effects of Ionizing and Non-Ionizing Radiations on Pronuclear Fusion, Cleavage, and Embryogenesis of Ascaris Eggs[1]

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Henshaw (1940) made the remarkable observation that exposure of the gametes of *Arbacia punctulata* to X rays caused no delay in the time schedule from entrance of the sperm head into the egg until the pronuclei were fused. Subsequent to fusion of the pronuclei, however, there was considerable retardation of the various mitotic processes. This observation, *a priori,* appears remarkable, since all dynamic biological processes have been shown to be more or less sensitive to the action of ionizing radiations, and there appears to be no obvious reason why this process should be an exception, since in many systems pronuclear fusion is highly sensitive to conditions within the cell.

After the observation in this laboratory that all eggs expressed from the terminal portion of the uteri of *Ascaris lumbricoides suum* are in the pronuclear stage, and that the pronuclei fuse only after relatively long periods of time (Bachofer, 1956), it appeared that these eggs afforded an excellent opportunity to check, with another organism, the observation of Henshaw on pronuclear fusion. These eggs, in addition, provide a means of securing highly quantitative and reproducible results on the effects of radiations on cell cleavage and embryogenesis, as well as response to postirradiation treatment (Bachofer and Pahl, 1955; Pahl and Bachofer, 1954).

The present study includes effects of X rays and of ultraviolet radiation (UV) on pronuclear fusion, on first cleavage, and on development of eggs into motile embryos, as well as the effect of postirradiation aerobic and anaerobic treatment on these three processes. These latter studies represent a part of a series of experiments designed to throw some light on possible mechanisms of recovery from radiation damage.

Acknowledgment.—The author is grateful to Mrs. Sophie Rothbard for valuable technical assistance in certain phases of this work.

Materials and Methods

All experiments in the present study were conducted with the eggs of *Ascaris lumbricoides suum.* The nuclear phenomena here described are quite different from those of the widely used and familiar eggs of *Ascaris megalocephala.*

Source of Eggs.—Approximately 100 large females were removed from the small intestines of hogs and placed in Kronecker's solution (7.5 g NaCl and 0.06 g NaOH per liter of water) and brought to the laboratory for immediate

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removal of the uterine eggs. The terminal 3 cm of each uterus was removed from the living worms, and the eggs expressed from the uteri onto a glass plate by pressure of a glass rod. The eggs were immediately placed in a physiological saline solution (Baldwin and Moyle, 1947) and stored at approximately 3° C until they were to be cleaned for use. Because of the importance of reproducible developmental rates in this study, considerable attention was given to the method of cleaning the eggs as well as the concentration of eggs in the incubation vials, since both can alter considerably the developmental rates.

Cleaning of Eggs.—NaOCl was used to clean the external protein coat from the eggs. Four concentrations (7×10^{-5}, 1.4×10^{-4}, 3.5×10^{-4}, and 1.75×10^{-3} M) were tested for their ability to clean the eggs. The eggs were added to these various concentrations and rotated slowly in an Erlenmeyer flask until a fine suspension of clean eggs, visibly free of clumping, remained in the supernatant solution. When, upon microscopic examination, the suspended eggs appeared free of their protein coats, they were separated from any remaining clumped eggs. Under these conditions, 10 minutes was found adequate for cleaning the eggs when 1.4×10^{-4} M and higher concentrations of NaOCl were used, but inadequate when 7×10^{-5} M NaOCl was used. Henceforth 1.4×10^{-4} M NaOCl solutions were employed in all cleaning procedures, since this concentration gave clean eggs with no evidence of damage. The eggs were washed with distilled water four times by centrifuging at approximately 400 g for 30 seconds and decanting the supernatant. The washed eggs were resuspended in *Ascaris* saline and stored at 3° C to serve as the stock for future experiments.

Damage to the egg coat was evident when the eggs were cleaned in higher concentrations of NaOCl. For example, one lot of eggs was added to 7×10^{-3} M NaOCl and slowly agitated for 10 minutes. At the end of this period the eggs were washed in the usual manner. These eggs, when incubated in *Ascaris* saline at 30° C, tended to clump together. It was deduced that damage to the egg coats permitted material to exude which tended to clump the eggs. Careful miscroscopic examination of the eggs revealed what appeared to be minute fissures in the coats. The concentration of eggs required to inhibit development when the eggs were suspended in *Ascaris* saline and incubated at 30° C was much lower with this stock than with those cleaned in low concentrations of NaOCl.

Incubation of Eggs.—In all of these rate studies it is of paramount importance to incubate eggs under as uniform conditions as possible. All eggs were incubated in a constant-temperature bath with water agitated and maintained at 30° ± 0.02° C. It is important that flat-bottom vials be used for incubation in order to avoid uneven packing of eggs which is encountered with various tapered and round-bottom vials. Normal settling of eggs produces this packing, which in turn produces inhibition of development when the packing reaches certain concentrations. Uniformity in the process of cleaning eggs is important in order to avoid inhibition of development. The relationship between cleaning process and inhibition due to packing is evident in the following considerations. In the following table only selected values from

TABLE 1.—Effect of concentration of NaOCl used in cleaning eggs and concentration of eggs during incubation on the percentage of eggs undergoing first cleavage at 40 hours and at 50 hours.

Concentration of NaOCl (M)	Concentration of eggs/cm²	Percent cleavage at 40 hours	Percent cleavage at 50 hours
1.4×10^{-4}	30,000	50	98
1.4×10^{-4}	60,000	50	98
1.4×10^{-4}	140,000	25	64
3.5×10^{-4}	140,000	15	53
1.75×10^{-2}	30,000	7	45
1.75×10^{-2}	60,000	4	5
1.75×10^{-2}	120,000	2	3

concentrations which show striking differences are included. The percentage of eggs that had undergone first cleavage after 40 hours and 50 hours of incubation was used as the criterion of damage. The concentrations noted are the actual number of eggs/cm^2 that settled on the bottom of the incubation vials. It is important to note that not the concentration/volume of suspending medium is important, but the actual number of eggs that are packed on the bottom of the vial, as indicated in table 1. The table shows clearly that both concentration of NaOCl, used in cleaning, and concentration of eggs during incubation are important in crucial rate studies.

Extensive tests at concentrations of 30,000, 40,000, 50,000 and 60,000 eggs/cm^2, cleaned with 1.4×10^{-4} M NaOCl, showed no inhibition of development. A concentration of 40,000 eggs per incubation vial, in 4 ml of *Ascaris* saline, was therefore chosen, since it gave adequate numbers for easy microscopic counting and was safely in the range within which no inhibition of development occurred.

Irradiation Procedure.—The X-ray machine was operated at 100 kv and 8 ma. The X-ray tube possessed a tungsten target and a beryllium window 1 mm thick, without added filtration. Eighty thousand eggs per millileter in *Ascaris* saline, obtained by appropriate dilution of the stock suspension, was used for all irradiations. The dose, previously evaluated at 12,000 r/min (Bachofer and Pahl, 1955) was re-evaluated at 12,500 r/min. All irradiations were carried out at exactly 25° C. This was accomplished by circulating water from a constant-temperature bath, by means of a centrifugal pump, through a brass sleeve containing the sample to be irradiated.

Monochromatic radiation at 2537 A, from a low-pressure, mercury-vapor germicidal lamp manufactured by General Electric Company, was used in the experiments. The 15-watt lamp was mounted in a specially-constructed cabinet with controlled temperature and ventilation. A shutter in the cabinet gave precise timing of exposures, and effectively cut off any stray or ambient ultraviolet radiation between exposures. The shutter also eliminated the necessity of turning off the lamp during the course of a series of irradiations, thereby giving a more uniform dose. All exposures were made at a distance of

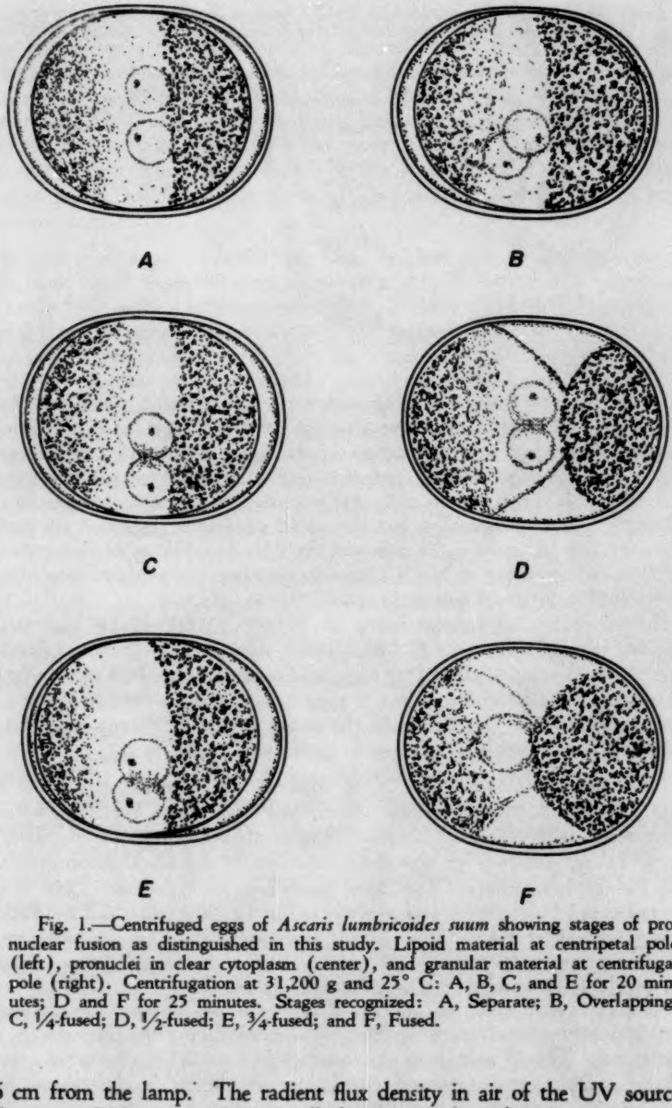


Fig. 1.—Centrifuged eggs of *Ascaris lumbricoides suum* showing stages of pronuclear fusion as distinguished in this study. Lipoid material at centripetal pole (left), pronuclei in clear cytoplasm (center), and granular material at centrifugal pole (right). Centrifugation at 31,200 g and 25° C: A, B, C, and E for 20 minutes; D and F for 25 minutes. Stages recognized: A, Separate; B, Overlapping; C, ¼-fused; D, ½-fused; E, ¾-fused; and F, Fused.

66 cm from the lamp. The radient flux density in air of the UV source at 66 cm was 780 ergs cm^{-2} sec^{-1}; all doses are indicated in terms of minutes of exposure.

Postirradiation Procedure.—Immediately after irradiation, 7 ml of *Ascaris* saline was added to the 1 ml of irradiated sample which was then divided into

two lots, one of which was incubated aerobically immediately at 30° C, the other deoxygenated for 30 minutes with nitrogen at room temperature. The sealed deoxygenated vials were then incubated at 30° C for 24 hours. At the end of 24 hours the vials were opened, aerated by forced bubbling of air, and incubated aerobically at 30° C. Unirradiated controls paralleled all irradiated samples.

Observation of Pronuclei.—Pronuclei are obscured in the cell by large amounts of dense yolk material and other granular material in the vicinity of the pronuclei. Visibility was enhanced by 1) compression of the cells and 2) centrifugation of the cells. The first method made use of a compression device which applied pressure to the slide and coverslip while microscopic observation of the eggs was in progress. After the eggs had become sufficiently flattened the pronuclei could be easily seen without obstruction by the yolk material. This method was utilized in all the preliminary investigations. It possessed the disadvantage of altering somewhat the shape of the pronuclei and this made it difficult at times to estimate the exact degree of fusion of pronuclei. Its chief advantage was the rapidity with which it enabled samples to be examined. It was extensively used for preliminary scanning of material. The second procedure involved centrifugation of eggs at a sufficiently high speed to separate the components of the cell as depicted in figure 1. The multispeed attachment for an International Centrifuge, Model SBV, which developed 31,200 g, was adequate to separate the components in 18 to 20 minutes at 25° C. At 35° C the time could be reduced to 10 or 11 minutes. If inadequate centrifugal force is used, the separation of lipoid material, clear cytoplasm, and granular material is incomplete and the pronuclei can be seen with difficulty. If excessive centrifugal force is used, a bluish, light-refracting band appears in the cytoplasmic layer and the pronuclei are obscured. Since with proper centrifugation the pronuclei could be clearly seen in undistorted form, this method was used throughout the present study for all quantitative values concerning pronuclei.

Glossary.—The experimental results, summarized in the figures and tables, are self-explanatory when the terms, as used in this report, are defined. The implications of the results will be considered in the discussion. The terms used in the figures and tables are explained in the following glossary.

AEROBIC: In equilibrium with air.

ANAEROBIOSIS; ANAEROBIC TREATMENT: Deoxygenation of egg suspension with purified nitrogen and storage of sealed vial at 30° C for 24 hours unless specifically stated otherwise (e.g., 48 or 96 hours).

CLEAVAGE TIME: Time in hours required for a given percentage of eggs to undergo first cleavage.

50% CLEAVAGE TIME: Time in hours required for 50% of the eggs in a given sample to undergo first cleavage.

CONCENTRATION: Total number of eggs per incubation vial as opposed to number of eggs per ml of solution. This designation has been adopted since the total number is important because of settling to bottom of vial.

FUSION; PRONUCLEAR FUSION: Dynamic process whereby male pronucleus and female pronucleus unite. Several stages of pronuclear fusion are recognized under the heading of "fusion stage."

FUSION STAGE: Degree of union of male and female pronuclei. Stages recognized in this study (fig. 1) are: *Separate.*—Pronuclei perfectly isodiametric with no sign of

joining, usually with definite space between pronuclei; occasionally juxtaposed or touching but lacking signs of union; strictly the stage *previous* to detectable fusion. *1/4-fused*.—Pronuclei showing early signs of union, characterized by the beginning of loss of isodiametric form; joining process detectable along area of membranes of approximately 1/4 the diameter of the pronuclei. *1/2-fused*.—Further development of stage above, characterized by greater loss of isodiametric form; fusion area approximately 1/2 the diameter of the nucleus. *3/4-fused*.—Further development of above. *Fused*.—Pronuclei completely united to form fusion nucleus. *Clear*.—The stage subsequent to the fusion process; transitional stage between pronuculear fusion and first cleavage, characterized by breakdown of fusion nucleus. Under ordinary light, the living, unstained cell appears clear in this region.

FUSION TIME; PRONUCLEAR FUSION TIME: Time required at 30°C for a given percentage of eggs to achieve 1/4-fused stage. All eggs which have passed through 1/4-fused stage plus all eggs in 1/4-fused stage at time of counting are scored as "fused."

50% FUSION TIME: Time in hours required for 50% of the pronuclei to achieve 1/4-fused stage.

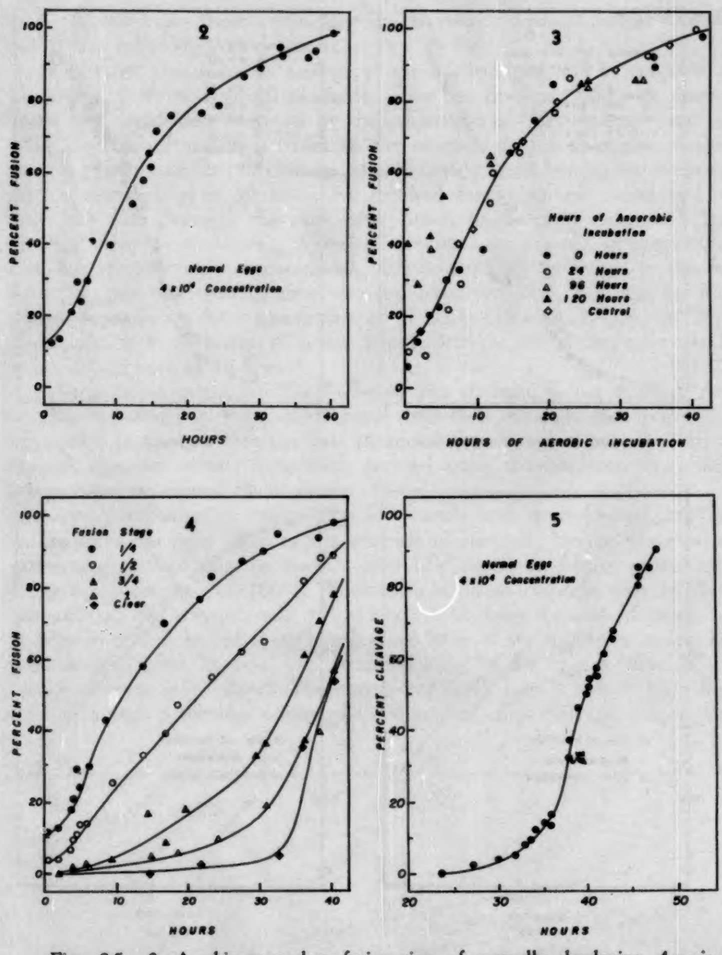
SURVIVAL: Completion of embryogenesis; development of motile embryo.

Results and Discussion

When eggs of *Ascaris lumbricoides suum* are removed from the terminal 3 cm of the uterus, approximately 98% of the eggs are fertilized and those that are unfertilized can be easily recognized by their elongated shape and distinctive contents. All of the eggs are in the pronuclear stage; of more than 100,000 eggs examined for pronuclear phenomena in this study, a fusion nucleus was never encountered in our cleaned stocks of eggs used for irradiation studies. In fact, by carefully timing the removal and cleaning processes, we have found that the stock of eggs, stored at 3° C, requires consistently 10 hours for 50% of the eggs to achieve the 1/4-fused stage, 22 hours for 1/2-fused stage, and 34 hours for 3/4-fused stage (fig. 4). Once the eggs have achieved complete fusion—average time for 50% is 38 hours—the nuclear membrane disintegrates (clear stage) within one hour and first cleavage is completed within two hours. This gives ample time for experimental procedures and for observation of nuclear phenomena. The time schedule is excellently adapted to rate studies on nuclear phenomena without the necessity of stopping vital processes by killing, staining, etc.

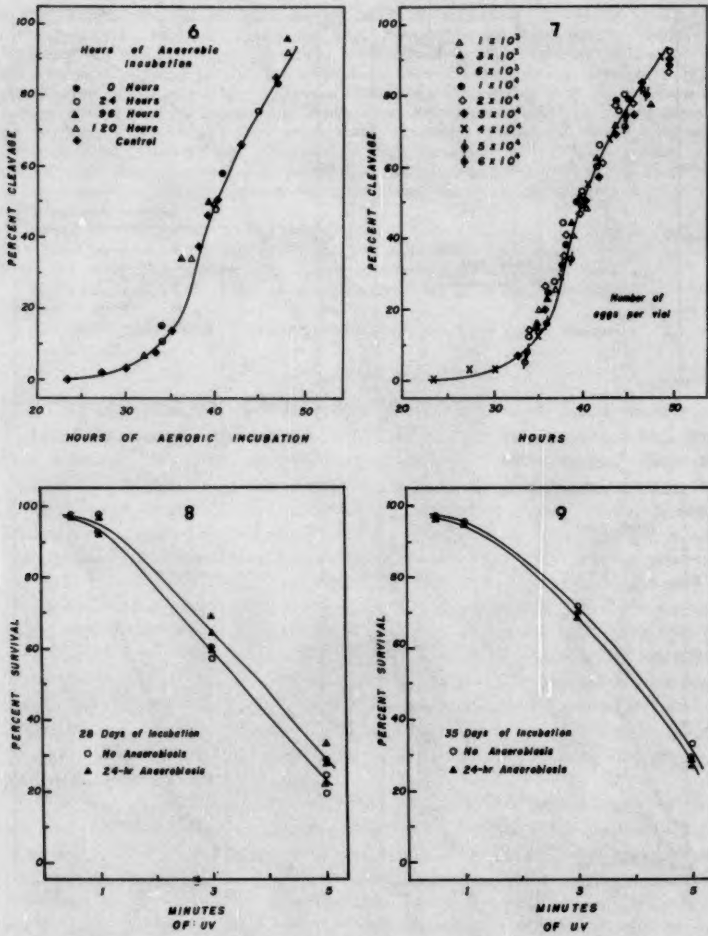
The importance assigned to 1/4-fusion in all the tables and figures is based on the fact that once this dynamic process has begun it proceeds to completion with amazing regularity, unless the cell or its constituents are damaged, and one of the earliest and most unfailing signs of nuclear damage, ultimately reflected in aberrations in cleavage and embryogenesis, is the delay in the early stages of pronuclear fusion. All subsequent discussion will be concerned, therefore, with the stage designated "1/4-fused," and all values will be for 50% fusion unless otherwise stated.

Effects of Ultraviolet-Irradiation.—The overall pattern, deducible from numerous UV-irradiations, shows pronuclear fusion very sensitive to even the lowest doses of UV. A dose delivered in 1/2 minute increases the time required for 50% pronuclear fusion by a factor of 2.8. With increase in dose there is a proportionate increase in delay of pronuclear fusion; a dose delivered in 5 minutes increases the time by a factor of 11. With cell cleavage, however, the relationships change completely. At the lowest UV dose there is an increase in the time required for 50% cleavage by a factor of only 1.2,



Figs. 2-5.—2. Aerobic pronuclear fusion time of normally developing *Ascaris* eggs incubated at 30° C. 3. Effect of duration of anaerobiosis on aerobic pronuclear fusion time of unirradiated *Ascaris* eggs. 4. Aerobic pronuclear fusion time of normally developing *Ascaris* eggs incubated at 30° C. Pronuclear fusion stages explained in text. 5. Aerobic cleavage time of normally developing *Ascaris* eggs incubated at 30° C.

whereas with the 5-minute irradiation there is an increase by a factor of more than 60. With increase in dose of UV, the cleavage delay increases approximately exponentially. From this we deduce that the factors controlling the mechanisms of nuclear fusion which are susceptible to UV irradiation are



Figs. 6-9.—6. Effect of duration of anaerobiosis on aerobic cleavage time of unirradiated *Ascaris* eggs. 7. Effect of egg concentration on aerobic cleavage time of unirradiated *Ascaris* eggs. 8. Percent survival after 28 days of incubation of *Ascaris* irradiated with various doses of UV. One series with and one series without anaerobic treatment. 9. Percent survival after 35 days of incubation of *Ascaris* irradiated with various doses of UV. One series with and one series without anaerobic treatment.

quite distinct from those controlling cell cleavage. This is further brought out by the following considerations.

It is often assumed that damage at the nuclear level will be reflected in the ability of the normal cell to divide. That this does not hold with *Ascaris* under UV irradiation is shown by the calculation of "net cleavage time" in table 2. This calculation is based on the assumption that pronuclear fusion, being a prerequisite for cell cleavage, should have a direct bearing on the latter. If, for example, when 10 hours are required for pronuclear fusion and 40 hours for first cleavage, the time from fusion to cleavage, designated "net cleavage time," is 30 hours. When cell processes are stopped, or checked, as with low temperatures or anaerobiosis, and subsequently permitted to proceed normally, this "net cleavage time" remains constant. But when eggs are irradiated to produce a 50% fusion time of 28 hours (18 hours delay), the 50% cleavage time is 48 hours (8 hours delay), and the net cleavage time is 20 hours (a decrease of 10 hours).

The question might be raised whether this decrease in net cleavage time actually represents a stimulation, since such cases, though rare, have been reported. It appears that the two processes, fusion and cleavage, which in normal eggs are closely correlated, proceed quite independently once their course has been altered by irradiation.

Upon completion of embryogenesis a motile embryo is formed and this motile form has been taken as the criterion of survival. Several observations concerning survival may be made. Low UV doses, capable of producing a delay in fusion time of 180%, produced a delay in cleavage time of 20%, but reduced the survival only 1%. High UV doses, capable of producing a delay in fusion time of 1100%, prevented 58% of the eggs from undergoing first cleavage after 35 days, but permitted 25% of the eggs to develop into motile embryos at 35 days. The unexpected result here is that at high doses of UV a high percentage of eggs fails to undergo first cleavage, but of those

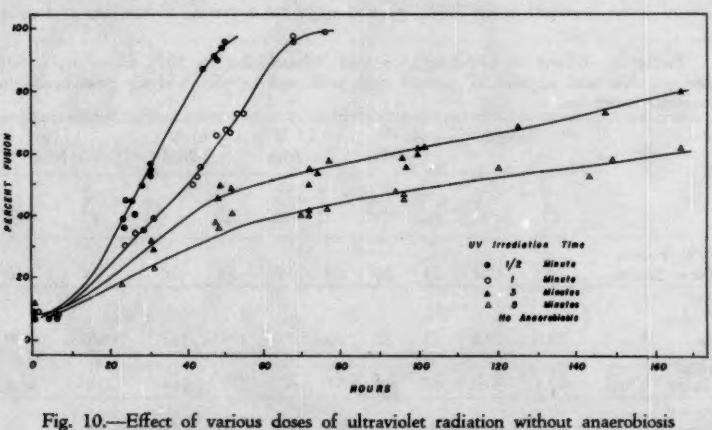


Fig. 10.—Effect of various doses of ultraviolet radiation without anaerobiosis on aerobic pronuclear fusion time of *Ascaris* eggs.

that do undergo first cleavage a high percentage (65%) continues development to the motile embryo stage. This is in sharp contrast to the situation with X rays, as will be shown.

X-ray Inactivation.—Only selected doses of X rays which will illustrate certain points will be considered. At relatively low doses, chosen to increase cleavage time by 50%, there is a 400% increase in pronuclear fusion time. Hence, contrary to the situation reported by Henshaw (1940) using *Arbacia,* the pronuclear fusion process with *Ascaris* is extremely sensitive to X-irradiation as well as UV-irradiation.

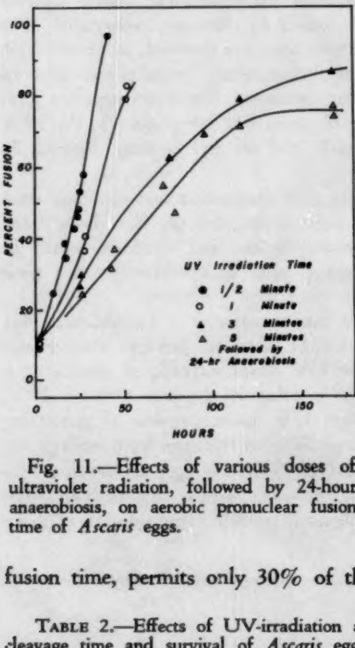


Fig. 11.—Effects of various doses of ultraviolet radiation, followed by 24-hour anaerobiosis, on aerobic pronuclear fusion time of *Ascaris* eggs.

X-irradiation shows, as has been shown with UV-irradiation, that the factors controlling the mechanisms of nuclear fusion, which are susceptible to irradiation, are quite distinct from those controlling cell cleavage. There is this difference, however, that at the higher X-ray doses cleavage is not drastically affected as with the higher UV doses. This is evident in table 2. But the situation reverses itself with survival. Whereas a UV dose which causes a 50% increase in pronuclear fusion time permits 95% of the eggs to survive, a comparable dose of X rays, which causes a 50% increase in pronuclear fusion time, permits only 30% of the eggs to survive. Likewise, a dose of

TABLE 2.—Effects of UV-irradiation and X-irradiation on 50% fusion time, 50% cleavage time and survival of *Ascaris* eggs with and without 24-hour post irradiation anaerobic treatment.

		Control		U V ½ Min		U V 1 Min		U V 3 Min		U V 5 Min	
		Deox	Aer	Deox	Aer	Deox	Aer	Deox	Aer	Deox	Aer
50% Fusion Time; Hours		10.1	10.2	25	28	34	39	49	56	74	110
50% Cleavage Time; Hours	Net	30.0	29.8	15	20	20	27	128	163	>400	>500
	Total	40.1	40.0	40	48	54	66	177	219	* a, b	* c, d
Percent Survival		99.6	99.5	98	98	95	95	69	71	35	27

TABLE 2.—(*continued*)

		X-ray 25 Kr		X-ray 50 Kr		X-ray 150 Kr		X-ray 250 Kr	
		Deox	Aer	Deox	Aer	Deox	Aer	Deox	Aer
50% Fusion Time; Hours		30	40	36	48	46	60	66	108
50% Cleavage Time; Hours	Net	23	22	25	23	50	44	96	80
	Total	53	62	61	71	96	104	162	188
Percent Survival		48	31	10	5	0	0	0	0

* did not reach 50% cleavage.

a) for 30% cleavage—270 hours
b) for 45% cleavage—2400 hours
c) for 30% cleavage—384 hours
d) for 46% cleavage—2400 hours

UV which causes a 6-fold increase in pronuclear fusion time also causes approximately a 6-fold increase in cleavage time and permits 70% of the eggs to survive. X rays, on the other hand, which give a comparable 6-fold increase in pronuclear fusion time, cause only a 2½-fold increase in cleavage time, but permit no eggs to survive. Whereas with UV most of the eggs that come through first cleavage eventually survive, with X rays most of the eggs that come through first cleavage at moderate to high doses never become motile embryos.

The results, in short, show that pronuclear fusion, as well as cell cleavage and embryogenesis, is susceptible to radiation damage. Three possibilities may be suggested for failure to observe retardation of pronuclear fusion in

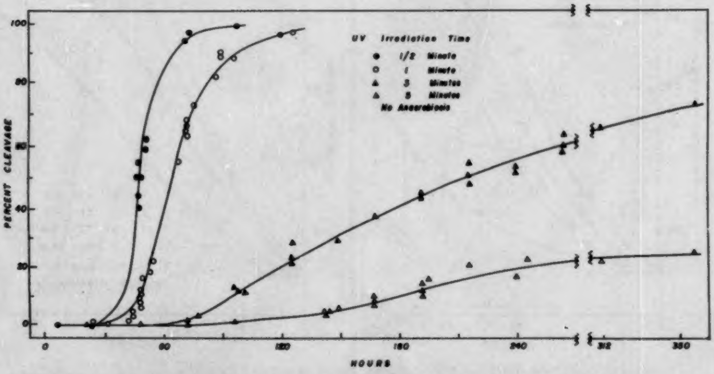
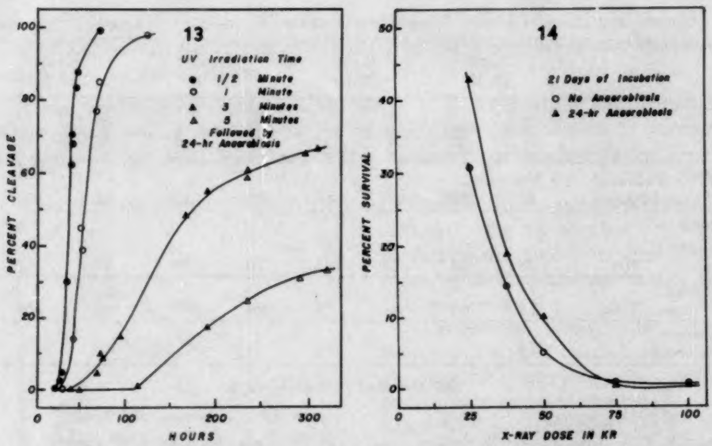
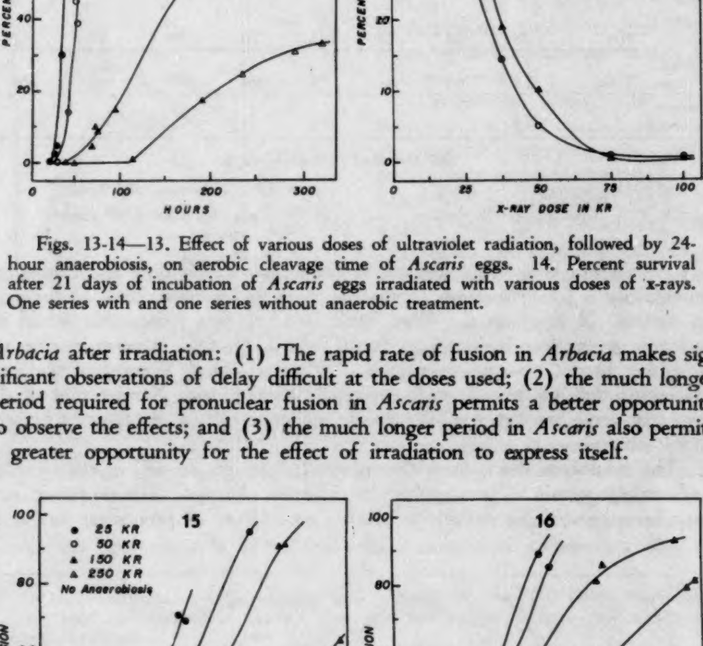


Fig. 12.—Effects of various doses of ultraviolet radiation, without anaerobiosis, on aerobic cleavage time of *Ascaris* eggs.



Figs. 13-14—13. Effect of various doses of ultraviolet radiation, followed by 24-hour anaerobiosis, on aerobic cleavage time of *Ascaris* eggs. 14. Percent survival after 21 days of incubation of *Ascaris* eggs irradiated with various doses of x-rays. One series with and one series without anaerobic treatment.

Arbacia after irradiation: (1) The rapid rate of fusion in *Arbacia* makes significant observations of delay difficult at the doses used; (2) the much longer period required for pronuclear fusion in *Ascaris* permits a better opportunity to observe the effects; and (3) the much longer period in *Ascaris* also permits a greater opportunity for the effect of irradiation to express itself.

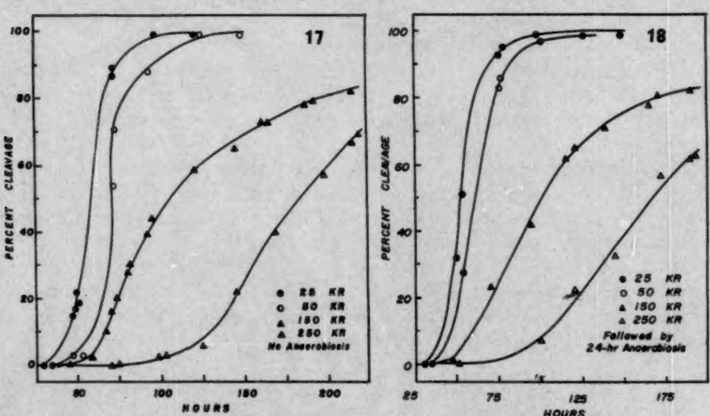


Figs. 15-16.—15. Effect of various doses of X rays, without anaerobiosis on aerobic pronuclear fusion time of *Ascaris* eggs. 16. Effect of various doses of X rays, followed by 24-hour anaerobiosis, on aerobic pronuclear fusion time of *Ascaris* eggs.

Anaerobic Treatment.—The fact that *Ascaris* is a facultative anaerobe makes it possible to hold the eggs anaerobically for long periods of time even at optimal incubation temperatures without detectable harm to the eggs. Eggs held for 96 and 120 hours anaerobically begin to show an increased number in the earliest stages of pronuclear fusion (fig. 3), but no change can be detected in the time required for first cleavage (fig. 6) nor in the ultimate number that develop into motile embryos (survival). After 24 hours of anaerobiosis no change can be detected in fusion time, cleavage time, or percent survival when the eggs are incubated aerobically at 30° C. This enables one to subtract out the time of anaerobiosis from all anaerobically-treated eggs, as has been done in all figures.

Postirradiation Recovery.—The recovery from radiation damage by postirradiation anaerobic treatment of *Ascaris* eggs in this laboratory represents the first time such a phenomenon has been described (figs. 8-18; table 2). Studies which superficially appear similar, such as those of Wolff and Luippold (1955), in which postirradiation anaerobiosis and KCN treatment of irradiated *Vicia* seeds prevented rejoining of chromosome breaks, merely show that oxidative metabolism is necessary for the vital processes under consideration. In the present study and in many others, deprivation of oxygen likewise halts activity and no effect is observed so long as there is no oxidative metabolism. The present study carries the problem much further: no development took place during anaerobiosis, but afterward, under aerobic incubation, recovery was evident and is attributable to the period of anaerobiosis, or KCN treatment as noted below.

This recovery is not due simply to the delay in vital processes that is caused by anaerobiosis, for these same processes can be delayed by lowered postirradiation incubation temperatures. Low temperatures, however, do not



Figs. 17-18.—17. Effect of various doses of X rays, without anaerobiosis, on aerobic cleavage time of *Ascaris* eggs. 18. Effect of various doses of X rays, followed by 24-hour anaerobiosis, on aerobic cleavage time of *Ascaris* eggs.

foster recovery (Bachofer and Pahl, 1955), but actually decrease survival and prolong the net time required for cell cleavage when the eggs are subsequently incubated at optimal temperatures. Unpublished results from this laboratory indicate that the cytochrome system may be involved, for essentially the same results can be secured by postirradiation exposure to KCN before the incubation period at optimal temperatures. Since anaerobic recovery from irradiation is greatest when deoxygenated eggs are held at optimal temperatures, it appears that anaerobiosis, as well as KCN treatment, functions in some way other than merely to prevent the cytochromes from carrying out oxidative processes that are necessary for the expression of the latent damage in the irradiated cell. While the cytochromes are being held in abeyance, a positive function, probably the anaerobic synthesis of proteins and other substances essential for recovery of the damaged cell, may take place.

SUMMARY

Eggs of *Ascaris lumbricoides suum* were irradiated with X rays and with ultraviolet radiation. Fertilized eggs were secured that were still in the pronuclear stage. It was therefore possible to ascertain the effects of irradiation on fusion of pronuclei, as well as cell cleavage and embryogenesis.

X-irradiated and UV-irradiated *Ascaris* eggs showed considerable delay in the initiation of pronuclear fusion, as well as delay in cell cleavage and prevention of embryogenesis. This was contrary to results reported with *Arbacia,* in which X-irradiation had no effect on the time required for fusion of pronuclei.

Sharp differences in the effects of X rays and of ultraviolet radiation were found. A dose of X rays capable of producing a 400% increase in the time required for the initiation of pronuclear fusion produced an increase of 50% in the time required for cell cleavage. This dose of X rays prevented 70% of the eggs from completing embryogenesis. On the other hand, a dose of ultraviolet radiation capable of producing a 400% increase in pronuclear fusion time increased the cleavage time 65% and permitted 95% of the eggs to complete embryogenesis. Higher doses of UV, however, checked cleavage much more efficiently than X rays, but permitted much higher survival than X rays.

All aerobic experiments were paralleled with anaerobic experiments designed to throw some light on possible recovery mechanisms. It was found that deoxygenation and incubation for 24 hours after irradiation before aerobic incubation, was capable of shortening the time required for fusion of pronuclei and for cell cleavage, as well as increasing the percentage of eggs that were capable of completing embryogenesis, with one possible exception, namely, survival after UV-irradiation at low and medium doses. Possible mechanisms involved in this recovery are considered.

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Studies on Ascaridia galli (Schrank, 1758)[1]

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Larval tissue phases in life cycles of Ascaridata are well known (Sprent 1954, Stewart 1918, Ransom and Cram 1921). Ackert (1923) stated that the larvae (apparently all) of *Ascaridia galli* anchor their anterior ends deeply among the intestinal villi, penetrate the intestinal glands, but seldom pass through the intestinal wall to migrate into other organs of the host (domestic chicken). Todd and Crowdus (1952), however, observed that although tissue penetration by larvae of this species occurred, it was infrequent and only rarely did the larvae migrate outside the intestinal lumen. These contentions suggested additional investigation on the life history of this species.

Materials and Methods

Infective eggs[2] were obtained from gravid *A. galli* which had been stored in 0.5% formalin at 30° C. The uteri were removed and macerated with a rubber policeman and each egg suspension (inoculum) prepared was calibrated prior to inoculation. The index of a given inoculum consisted of the mean number of infective eggs obtained from five counts of equal volumes of the suspension. Since Moran (1954) demonstrated that 800 infective eggs per bird yielded maximum recovery of worms, this dosage was used in the present work except where otherwise stated. Birds were infected with eggs introduced by means of a calibrated Luer-Lok syringe, and a catheter which was inserted into the crop of White Leghorn or White Plymouth Rock chicks.

At autopsy the small intestine was removed and divided into three sections of approximately equal lengths: 1) *first or pancreatic section* (from gizzard to a point 1-3″ posterior to entrance of bile ducts), 2) *second or yolk-sac section* (from posterior limit of first section to yolk-sac diverticulum), 3) *third or caecal section* (from posterior limit of second section to origin of caeca).

Examination of the gut was accomplished as follows: *Free larvae*: The contents of each intestinal section were flushed with pressure into Erlenmeyer flasks with warm water according to the method of Ackert and Nolf (1929) and the larvae were counted with the aid of a binocular dissecting microscope. All specimens were preserved in 10% formalin. *Mucous larvae*[3]: After flushing, the intestinal sections were split lengthwise and stored in physiological saline at 4° C. On the following day[4] the mucus was carefully scraped from

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[1] A portion of a thesis submitted by the senior author to the University of Notre Dame in partial fulfillment of the requirements of the degree of Doctor of Philosophy. The present address of the senior author is Russell Sage College, Troy, New York.

[2] Eggs were considered infective after the larvae had undergone the first molt (Alicata 1934).

[3] "Mucous larvae" refers to those in the layer of mucus, lining the intestinal wall.

[4] This delay was necessitated because of the time required for the examination of intestinal contents for free larva, and only when more than five birds were autopsied at one time.

the gut wall with a blunt probe during observation with a binocular dissecting microscope. After scraping each section, the gut was cleared in 4% NaOH for 10 minutes and examined microscopically for larvae which may have been overlooked. The removed mucus was cleared in 4% NaOH and larvae were collected with the aid of a binocular microscope.

DISCUSSION

The life cycle of *Ascaridia galli* is direct (Ackert 1931). Males and females reside in the intestine of the domestic chicken and the uncleaved eggs are eliminated with the feces. Under favorable conditions (30° C in tap water) the zygotes develop into infective larvae in 16-20 days at which time the first molt has occurred. After ingestion by fowls, the larvae hatch and undergo three additional molts, reaching sexual maturity in approximately 50 days. Adult males average 6.3 cm and mature females 8.8 cm long (Ackert 1931).

Ackert (1931) stated that "the normal habitat of *A. lineata* [*A. galli*] is the duodenum, especially a portion which is a few centimeters posterior to

TABLE 1.—Larvae recovered from chicks inoculated when five days old

Days After Infection	Intestinal Sections		
	First	Second	Third
6	0	66	92
8	0	39	58
8	0	79	109
10	0	117	88
12	0	41	108
13	64	19	19
13	29	28	72
14	74	44	86
14	135	40	31
15	19	6	19
15	38	52	26
16	5	16	54
16	19	6	15
17	13	0	2
17	8	3	15
18	5	12	64
18	13	13	17
19	19	8	84
19	15	3	10
20	3	0	0
20	1	39	33
21	0	0	1
21	0	0	2
22	0	0	8
22	0	0	4
23	0	0	15
23	1	0	0
Total	461 (21.7%)	631 (29.7%)	1032 (48.58%)

TABLE 2.—Larvae recovered from chicks inoculated when 14 days old

		Intestinal Section							
		Flushing			Mucus				
	Days After Infection	First	Second	Third	1	2A	2B	3A	3B
2nd Stage Larvae	1	0	12	8	4	57	80	79	28
	2	0	0	0	0	8	23	12	5
	3	0	0	0	0	15	102	14	2
	4	0	10	14	1	30	120	151	15
	5	0	5	9	0	33	132	36	3
	6	0	2	2	0	8	31	63	55
	7	0	0	4	0	3	104	153	6
	8	0	12	3	1	1	256	107	1
		0	41	40	6	155	848	615	115
3rd Stage Larvae	9	0	9	130	8	6	25	30	38
	10	1	50	46	6	7	52	66	6
	11	0	4	2	12	34	23	45	12
	12	2	22	91	83	48	151	203	16
	12	12	15	8	50	33	0	0	3
	13	0	3	125	7	0	42	467	39
	13	24	16	10	67	8	12	6	5
	14	1	5	67	53	9	17	190	45
	14	1	1	17	10	0	0	0	1
	15	0	1	14	49	15	7	59	5
	15	2	0	1	16	1	0	2	1
	16	0	0	8	2	1	2	40	3
	16	0	6	3	2	1	0	1	0
	16	0	0	2	5	0	8	35	7
		43	132	524	370	163	339	1144	181
4th Stage Larvae	17	0	3	11	19	26	25	142	81
	17	2	8	3	12	4	6	3	2
	18	0	0	1	18	4	3	0	8
	19	0	1	57	6	7	18	27	88
	20	0	5	8	6	3	16	26	9
	20	0	0	1	6	2	2	0	9
	21	0	1	2	1	1	11	10	4
	22	1	0	0	2	0	1	1	1
	23	0	2	22	4	9	37	20	20
	24	0	0	1	3	5	18	16	9
	25	0	2	7	5	3	12	10	8
		3	22	113	82	64	149	255	239
	Total	46	195	677	458	382	1336	2014	535
	Percent	(8.9)	(33.9)	(57.3)					
								Total	5643

the entrance of the bile ducts . . ."[5] He further observed that the region of the yolk-sac diverticulum is posterior to the normal habitat and that healthy *A. galli* are never found in the intestine at the origin of the caeca.

In order to determine the location of the larvae after hatching, 32 five-day-old chicks were inoculated (experiment 1). Daily autopsy of one bird[6] and examination of the first and second sections ("normal habitat") of the intestine revealed no larvae for the first five days. These negative results prompted examination of the third intestinal section on the sixth day. Numerous larvae were recovered from this and also from the 2nd section of the gut. Larvae were found consistently in the 3rd section of the intestine throughout the remainder of this experiment (table 1). Of a total of 2124 larvae recovered, 461 or 21.7% were removed from the first section, 631 or 29.7% from the second, whereas 1032 or 48.5% were present in the third section of the intestine.

A second experiment was planned to 1) determine the location of *A. galli* larvae during the first five days after infection, 2) confirm the observations in the above experiment, and 3) define more specifically the location of the larvae in the intestine. Thirty-three fourteen-day-old chicks were inoculated and one of these was autopsied daily from the 1st-11th days and 18th-25th days after infection. Two birds were examined daily from the 12th-17th day to 1) furnish additional information on larval tissue penetration observed during this period in experiment one, and 2) test the validity of the authors' examination technique (microscopic) against digestion procedures.

Examinations for the first five days after inoculation revealed a total of 1009 larvae (table 2). Of these, 5 or 0.5% were recovered from the 1st section, 627 or 62.1% from the 2nd, and 376 or 37.3% from the 3rd section of the gut. It is entirely possible that worms in the 1st and 2nd sections of the gut in experiment 1 were overlooked because of small size and lack of observational experience. It is interesting to note that 37.3% of the larvae were recovered in the 3rd section of the gut during the first five days of parasitism.

The data presented in table 2 have been divided into three periods which are based on the presence of 2nd-(1-8 days), 3rd-(9-16 days), and 4th-stage larvae (17-25 days). Table 4 shows that only 6 larvae (0.3%) were recovered from the first section of the gut during the 2nd-stage larval period, whereas 1044 (57.4%) were taken from the 2nd section and 770 (42.3%) from the 3rd section for the same period. The presence of 42.3% of the worms in the 3rd section of the gut apparently explains why Tugwell and Ackert (1952) found relatively few larvae during the 2nd-stage larval period in similar experiments in which only the 1st and 2nd intestinal sections were examined. During the 3rd- and 4th-stage periods, larvae became more numerous in the first and third sections of the gut. Table 4 shows that for the 3rd-

[5] The "duodenal habitat" is actually in the jejunum according to Calhoun (1954) who states: "Three pancreatic and two bile ducts enter [intestine] at a point approximating the junction of the duodenum with the remainder of the small intestine. The jejunum and ileum, between which there is no line of demarcation. . . ."

[6] Two birds were killed daily after the 12th day of parasitism. Birds were fed Chick Startena.

TABLE 3.—Larvae recovered from chicks in four experiments

Experiment Number	Days from Infection to Autopsy	Number of Birds	Intestinal Sections First	Second	Third	Total Worms All Sections
1	6-23	25	460	631	1032	2123
2	1-25	33	504	1913	3226	5643
5	24	30	85	509	454	1048
7	50	20	10	62	126	198
Total		108	1059	3115	4838	9012
Percent			(11.7)	(34.5)	(53.6)	

stage larval period (9-16 days), the larvae recovered from intestinal sections 1, 2, and 3 were 413 (14.3%), 634 (21.9%), and 1849 (63.8%) respectively. Corresponding figures for the 4th-stage larval period (17-25 days) are 85 (9.2%), 235 (25.4%), and 607 (65.5%). Of 5643 worms recovered for the whole experiment, 504 (8.9%) were in the first section, 1913 (33.9%) in the 2nd, and 3226 (57.2%) in the 3rd intestinal section. This confirms observations in experiment 1 which indicated the posterior section of the intestine to be an important and heretofore unrecognized habitat of *A. galli*.

To elucidate more specifically the location of the larvae, the 2nd and 3rd intestinal sections were each divided after flushing into equal parts, namely, 2A, 2B; 3A, 3B. Table 2 shows that 25.4% (1433) of the larvae were localized in section 2B and 41.6% (2352) in section 3A of the intestine. This part of the gut is situated 3-5 inches[7] on each side of the yolk-sac diverticulum. Unfortunately, gut sections 2 and 3 were not divided until after flushing. The above percentages include 50% of the free larvae in intestinal sections 2 and 3 on the assumption of uniform distribution in these sections of the gut. This information supplements data in experiment 1 and refutes previous contentions that larvae are not found posterior to the yolk sac diverticulum.

Table 3 summarizes tables 1, 2, and additional information from experiments 5 and 7. It shows that for a total of 9012 larvae recovered from 108 infected birds, 1059 or 11.7% were located in the first section, 3115 or 34.5% in the second section, and 4838 or 53.6% in the third section of the gut. These data (table 3) give a better picture of intestinal distribution of worms since they are more comprehensive. Further, table 3 shows a similar distribution of worms was present in experiments 1, 2, and 5, in which birds were autopsied from the first and twenty-fifth days after inoculation. Birds in experiment 7 were autopsied fifty days subsequent to inoculation.

A statistical test (Cox 1952) for the homogeneity of the worm population recovered from 33 infected birds in experiment 2, was applied to the data in table 2. The critical Chi-square value for one percent significance and four

[7] The length of this section of the gut varies (as indicated) with the age of the host during this period of rapid growth.

degrees of freedom is 13.277. As may be seen, (table 4) the experimental Chi-square of 786.19 is approximately 60 times this value, therefore significant fluctuations in worm population occurred during the three periods of the experiment. Table 4 shows that approximately 38% of the total Chi-square value was contributed by second-stage larvae recovered from section 2. Subsequent loss of 34.4% of the worms from this section in period 2 (9-16 days) and increase in those recovered in sections 1 (14.0%) and 3 (23.4%) indicate a population shift to these intestinal sections. During period 3 (17-25 days) further population shifts were evidenced by a decrease of 5.1% in section 1 and increases of 2.4% and 1.7% in intestinal sections 2 and 3, respectively. It is interesting to note that the greatest shifts in population occurred in period 2 which corresponds to the period when tissue penetration by larvae of *A. galli* was observed.

TISSUE PHASE

Ackert (1923) presented the first evidence of a larval tissue phase of *A. galli* and stated that specimens could be observed attached to the intes-

TABLE 4.—Summary of table 2 and a statistical test of homogeneity of the worm population

Periods	Intestinal Sections: First	Second	Third	Total
2nd stage larvae	6 (0.3%)	1044 (57.4%)	770 (42.3%)	1820
3rd stage larvae	413 (14.3%)	634 (21.9%)	1849 (63.8%)	2896
4th stage larvae	85 (9.2%)	235 (25.4%)	607 (65.5%)	927
Total	504 (8.9%)	1913 (33.9%)	3226 (57.3%)	5643

Intestinal section	Observed	Calculated	Obs. – Calc.	$\frac{(O-C)^2}{C}$
First	6	163	–157	151.22
	413	259	154	91.57
	85	82	3	0.11
	(504)	(504)		
Second	1044	617	427	295.51
	634	982	–348	123.32
	235	314	– 79	19.88
	(1913)	(1913)		
Third	770	1040	–270	70.96
	1849	1655	194	22.74
	607	531	76	10.88
	(3226)	(3226)		
	5643	5643		786.19

For degrees of freedom = 4; x^2_{01} = 13.277.

tinal wall and further that examination of stained sections revealed they were in the spaces between the villi and partially embedded in the intestinal glands. Ackert (1931) observed that the larvae remained in the lumen during the first nine days after hatching and that from the 10th-17th day they could be readily found with their anterior ends inserted into the intestinal mucosa; these larvae were observed to withdraw by the 18th day.

Tugwell and Ackert (1952), utilizing a digestion technique for the recovery of tissue-phase larvae from the gut wall, presented evidence that indicated the tissue-phase may begin on the first day and may occur as late as the 26th day of parasitism, but that the majority of the larvae undergo this phase from the 8th-17th day after hatching. However, Todd and Crowdus (1952) indicated that tissue penetration was rare and that most of the larvae were found in the lumen of the intestine at 7 and 14 days after inoculation.

Present observations from experiment 1 indicate that few larvae actually penetrate the host tissue. Of 1421 larvae recovered from all intestinal sections after flushing, 1410 (99.9%) were located in the layer of mucus lining the gut. Larvae apparently in close association with the intestinal mucosa were observed first on the 13th day when six were recovered from the 2nd intestinal section of one bird. Thereafter in this experiment, one such larva was found in one bird each on the 14th (1st section), 15th (3rd section), and 16th days (1st section) and two from one bird on the 17th day (2nd section). Sections of two of the six larvae recovered on the 13th day and one larva recovered on the 15th day, showed that penetration of the intestinal mucosa had not occurred.

Lack of agreement with Ackert's findings prompted further attention to tissue-phase larvae in experiment 2 during which one infected bird was examined daily from the 1st-25th days after inoculations, with duplicate examinations from the 12th-17th days. Of a total of 5643 larvae, only 37 (0.65%) were observed in close association with the intestinal mucosa and all of these were observed from the 12th-17th days of infection. Histological sections revealed that of the 37 specimens, only 23 of these had penetrated the intestinal mucosa and apparently produced cellular damage. The remaining 14 larvae were merely located in intervillar spaces. Observations in the present experiment indicate that penetration of the intestinal mucosa by larvae of *A. galli* is very infrequent (0.41%).

Tugwell and Ackert (1952) flushed larvae from the intestinal lumen and then digested the intestine on the assumption that all larvae that remained after flushing were in the tissue phase. It is obvious that this assumption was erroneous because the present authors, have shown that of the larvae *not* removed by flushing, 99.59% were in the surface mucus lining the gut and only 0.41% of the larvae were embedded in the tissues.

An experiment was planned to determine the degree of error in the present microscopic examinations of the intestinal mucosa for the recovery of mucous and tissue larvae. Intestinal sections from one bird were examined daily from the 12th-17th day after inoculation. Subsequent to microscopic examination each intestinal section was digested in 1% pepsin in 0.5% HCl solution at 37.5° C and the material examined with a binocular dissecting microscope.

For the whole experiment only two larvae (0.54%), escaped the microscopic examination.

HATCHING OF INFECTIVE EGGS

Itagaki (1927) stated that eggs of *A. galli* hatch in the proventriculus but Ackert (1931) placed the site of hatching in the duodenum of the domestic fowl. Ackert (1923) and Guberlet (1924) observed active larvae in the intestine 24 hours after inoculation. In an attempt to clarify this point four 15-day-old chickens were each inoculated with 1 ml of a 1% methylene blue solution containing 2200 infective eggs of *A. galli*. Birds were examined 15 minutes, 30 minutes, 2 hours, and 24 hours subsequent to inoculation. At autopsy the crop, proventriculus, gizzard, and intestinal sections 1, 2, and 3 were placed in individual petri dishes, split lengthwise, and examined microscopically.

Fifteen minutes after inoculation the dye had progressed to a point five inches anterior to the end of section 2. Examination revealed infective eggs but no hatched larvae, in the first intestinal section and that portion of the second section to the point where dye was present (table 5). After 30 minutes the dye had progressed to a point one inch posterior to the end of section 2 and active larvae were recovered from intestinal sections 1, 2 and that part of section 3 where dye was present. Two hours after inoculation, dye was present at a point one inch anterior to the end of section 3 (origin of the caeca). Active larvae were recovered from section 2 and section 3 where dye was present. Twenty-four hours after inoculation dye and active larvae were present throughout the intestine, with the latter exhibiting localization in the 2nd and 3rd intestinal sections (table 5). Substantial recovery of larvae (36.6%) after 24 hours indicates that the majority of infective eggs had hatched, however, hatching occurred as early as 30 minutes after inoculation (table 5).

To determine the site of hatching, three 18-day-old chickens were anesthetised, the intestine clamped with hemostats immediately posterior to the proventriculus (chick 1), gizzard (chick 2) and bile ducts (chick 3). Each bird was inoculated with 2200 infective eggs. Examination of chick 1 tract 30 minutes after applying the clamp revealed large numbers of infective eggs

TABLE 5.—Larvae recovered from chicks inoculated with 2200 infective eggs of *A. galli*

Time from Inoculation to Autopsy	Intestinal Sections					
	Free Larvae			Mucous Larvae		
	First	Second	Third	First	Second	Third
15 minutes	*			*		
30 minutes	0	20	9	2	10	0
2 hours	0	17	0	0	15	1
24 hours	0	36	24	12	413	321

blank = no dye present * infective eggs only

in the crop and proventriculum but no free larvae. Neither were active larvae recovered from chick 2, but many infective eggs were observed in its crop, proventriculus, and gizzard. Examination of chick 3 revealed 56 active larvae in intestinal section 1 and infective eggs in the crop, proventriculus, and gizzard. These data indicate that the infective eggs hatch in the intestine but not in the crop, proventriculus, or gizzard. This point was clarified further by anesthetising a 20-day-old bird and clamping the intestine at the junction of the gizzard and duodenum, and also two inches posterior to the bile duct. The section of the gut between these two points was inoculated with 2200 infective eggs by introducing the catheter into a small incision. Examination of this section after 30 minutes revealed 76 active larvae and many infective eggs. This substantiates the above contention that the infective eggs hatch in the intestine and as early as one-half hour after infection.

GROWTH AND DEVELOPMENT OF A. GALLI

In experiments 1 and 2, 784 of the larvae recovered from daily examinations were measured and examined microscopically for evidence of molting. In *A. galli* the first molt occurs in the egg (Alicata 1934) after which the larvae are infective. Newly hatched larvae average 0.32 mm in length, are thick bodied, and possess a long rhabditiform esophagus. The 2nd molt was observed 6-8 days after hatching, and produced the 3rd stage larvae with a characteristic sickle-shaped tail and a preanal swelling in males and an anal prominence in both males and females. Growth during the first 8 days was gradual, the average daily increment in length being 0.2 mm for free larvae and 0.14 mm for mucous larvae (table 6). The 3rd molt was observed on the 14-16th days when 4th-stage larvae appeared. The females of this stage possess shorter tails than males and the latter possess a preanal sucker. For the 9-16 day period the free larvae averaged 0.01 mm in daily length increment and mucous larvae exhibited 0.09 mm in this period. The occurrence of the 4th molt was not observed in experiments 1 and 2, however, Ackert (1931) and Tugwell and Ackert (1952) observed it to occur between the 18-22nd day. Juvenile *A. galli* possess predominantly adult characteristics and 20-day-old juveniles averaged 11.6 mm while digestion larvae averaged 3.4 mm in length (Tugwell and Ackert 1952). During this period (17-24 days) of experiments 1 and 2, free larvae showed a daily length increment of 0.07 mm and mucous larvae only 0.01 mm.

Growth during the three periods departed considerably from that observed by Tugwell and Ackert (1952). In the present investigation the growth for free and mucous larvae for the first 8 days was 1.6 mm and 1.1 mm respectively as opposed to 2.0 for each type of larva of Tugwell and Ackert. For the 9-16 day period corresponding figures were 0.4 mm and 0.7 mm as opposed to 7.9 mm and 1.2 mm of Tugwell and Ackert, and 0.6 mm and 0.1 mm as opposed to 5.8 mm and —0.8 mm of Tugwell and Ackert for the 17-24 day period. Since Tugwell and Ackert apparently overlooked more than 50% of the larvae by not examining intestinal section 3, the relatively large numbers of larvae of shorter length from this part of the gut would undoubtedly offset to some extent, if not completely, the difference in length between larvae observed by these authors and those in the present work.

In experiments 1 and 2 the present authors observed that mucous larvae recovered in intestinal section 3 were consistently shorter than those from sections 1 and 2. Unfortunately no data are available to substantiate this contention since the necessity of isolating larvae recovered from each intestinal section was not foreseen.

Ackert (1931) reported that *A. galli* reached sexual maturity in approximately 50 days, however, Kerr (1955) reported that it occurred after only 30-35 days of parasitic existence. In experiment 7, examination of infected birds 50 days subsequent to inoculation, revealed 198 worms with an average length of 3.0 mm, however, these worms varied from 1.2-31.9 mm. The longest worms were recovered in section 1 whereas the smallest (63% of total number of worms) were recovered in the surface mucus lining the 3rd intestinal section. These data indicate that all larvae do not reach sexual maturity in 50 days and that many larvae may exist in a "static" condition for considerable periods in the layer of mucus lining the intestine. Further investi-

TABLE 6.—Lengths of free and mucous larvae recovered in experiments 1 and 2

Days After Inoculation	Av. Length of Larvae in mm: Free Larvae	Mucous Larvae	Average Length
1	0.38 (5)*	0.38 (5)	0.38
2	–	0.41 (6)	0.41
3	–	0.44 (5)	0.44
4	0.69 (5)	0.65 (10)	0.67
5	0.99 (5)	0.97 (10)	0.98
6	1.11 (20)	1.11 (20)	1.11
7	1.14 (4)	1.12 (10)	1.13
8	1.89 (4)	1.42 (9)	1.64
mean daily increment	(0.20)	(0.14)	
9	1.79 (5)	1.46 (10)	1.62
10	2.13 (25)	1.60 (12)	1.86
11	2.11 (5)	2.11 (7)	2.11
12	2.02 (38)	2.28 (14)	2.15
13	2.34 (25)	1.75 (38)	2.04
14	3.24 (32)	2.44 (19)	2.84
15	2.87 (16)	1.27 (24)	2.07
16	2.17 (28)	2.12 (30)	2.15
mean daily increment	(0.38)	(0.70)	
17	2.46 (30)	2.43 (28)	2.45
18	2.80 (28)	3.42 (33)	3.07
19	2.63 (46)	2.04 (23)	2.33
20	2.31 (36)	3.57 (11)	2.94
21	4.04 (2)	1.40 (5)	2.72
22	2.16 (10)	2.70 (5)	2.43
23	2.23 (11)	3.12 (15)	2.67
24	2.72 (20)	2.20 (18)	2.70
mean daily increment	(0.60)	(0.08)	

* Numbers in parentheses indicate the number of larvae measured.

gation of this phenomenon is of importance, especially relative to the action of anthelminthics.

SUMMARY

The present investigation revealed that the posterior third of the intestine of the domestic chicken is a significant and heretofore unrecognized habitat of larval *Ascaridia galli*. The greatest concentration of larvae was in a section of the gut extending 3-5 inches on each side of the yolk-sac diverticulum.

Significant larval population shifts from the middle third of the intestine to the anterior and posterior thirds of the intestine occurred between the 8th and 16th day after inoculation. Further population shifts toward the posterior third of the intestine occurred between the 17th and 24th day after inoculation.

Penetration of the intestinal mucosa by *A. galli* was rare (0.41%). After flushing 99.59% of the remaining larvae were located in the surface layer of mucus, lining the intestine.

The technique used by Tugwell and Ackert (1952) was found invalid for separating mucous larvae (in mucus next to gut wall) and tissue-phase larvae (embedded in gut wall).

Infective eggs hatch as early as 30 minutes after inoculation. This occurs in the anterior third of the intestine but not in the crop, proventriculus, or gizzard.

Of the four characteristic molts of this nematode, the 1st occurred in the egg, the 2nd was observed 6-8 days after inoculation, and the 3rd, 14-16 days after inoculation. The occurrence of the 4th molt was not observed, though it is reported to occur 18-22 days after inoculation.

Growth of free and mucous larvae during the first 8 days averaged 1.6 mm and 1.1 mm respectively; during the period from the 9th-16th day, 0.4 mm and 0.7 mm respectively; and during the period from the 17th-24th day, 0.6 mm and 0.1 mm respectively. Large numbers of consistently shorter larvae were recovered from the posterior third of the intestine.

Immature *A. galli* recovered 50 days after inoculation in the surface mucus, lining the intestine indicate that larvae may exist in a "static" condition for considerable periods.

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Light-Trap Survey of the Culicoides of Oklahoma[1] (Diptera, Heleidae)

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This survey is an extension of the study which was carried on in the Wichita Refuge (Khalaf, 1952). It is based on adult collections taken from New Jersey-type light-traps. In general, the location of the traps was close to bodies of water that might serve as breeding sites. From such collections 87,174 specimens of *Culicoides,* from various parts of the state, were recovered.

The techniques followed were essentially the same as those described for the work on the Wichita Refuge. Five more stations, widely separated from each other, were studied about as extensively as that of the Wichita Refuge. In each of the remaining stations studied, the work was based on selected days from the seasonal collection of that station. The selection was made by arranging the daily collections of the station in their sequence in the season with the lids of the cartons open and choosing superficially representative days.

The collections from some of the stations were made in 1946, others in 1947, and still others in 1948. The collections of these three years are collectively treated for predicting the general trends in the distribution, the density, and the seasonal incidence. This is not an uncommon practice in studying populations in other fields. The collection of a certain year in an area is never identical with that of the next year, even if the ecological conditions in the two years seem to be the same. Accordingly, a better understanding of the population behavior would result if material from many seasons were available. However, it seems that the correlation between collections of two years is higher than might be expected.

The study of Lake Overholser on a collection made in 1947 is supported by partial collections taken in 1946. The density and the behavior of each species were very similar in the two seasons. In addition, all the species that were found in 1947 were represented in 1946 except two rare ones, in spite of the limited sample in the latter year. This correlation between the collections of different years is utilized in this work to use the seasonal collection as a basis for prediction. It seems, however, that the highest incidence may fall in any suitable month. In 1947 there was no peak in June and August comparable to that of 1946. The behavior of the rare species in the two years is also noteworthy. In one year, one or more species may be missing. This feature of incidence finds its way in the frequent shortage in the list of the observed species for a station, compared to that of the association to which it belongs.

There is also a question as to how effective the light-trap is as a sampling

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[1] This paper is a portion of a thesis submitted to the University of Oklahoma in partial fulfillment of the degree of Doctor of Philosophy.

device. Hill (1947), working with some British species, came to the conclusion that the collection made by this method of sampling is a fair representative for the immediate vicinity. However, since different species are involved in Oklahoma, there is the possibility of "selection." The location of the trap in relation to the breeding sites and to the centers of concentration of the different species or even of the different sexes is often a source of bias. In addition, different species or even different sexes may differ in their attractivity to light. These two factors should always be taken into account in the interpretation of data for distribution and density purposes or for incidence study.

Light-traps operated nightly throughout the season pick up a section which is the top part of the curve of seasonal incidence. Improperly located traps and low attractivity to light of a species will naturally result in cutting a smaller section of the curve of the genus or of the particular species. The densities of the genus as a whole or of certain species may appear to be low, the date of appearance may be late and the disappearance may be early, and when there is a differential effect on the different species, comparisons may be invalid. In the body of this work, more will be said about the relation of this sampling method in the results.

In this work, it proved useful to apply a uniform terminology to refer to the density of the species or that of the genus as a whole within the station. "Rare" (low density) indicates maximum daily collection of less than ten; "occasional" with maximum in tens; "common" with maximum in hundreds; and lastly "abundant" with maximum daily collection in thousands. In the distribution maps these four density categories are differentiated by the size of the dots. It should also be mentioned that in the discussion of the appearance and the disappearance of the genus or the species, a few scattered early appearing specimens were neglected. The same is true with a few scattered specimens persisting late in the season.

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ECOLOGICAL CONDITIONS IN OKLAHOMA

The state of Oklahoma is situated where many of the biotic associations meet. The Oak-Pine Forest from the southeast meets the Oak-Hickory Forest extending from the northeast. Both these two associations diffuse further west in the form of the Postoak-Blackjack Forest. This last mentioned forest meets the prairie of the west. Of the latter, the association lying in the extreme east, is the Tallgrass Prairie which is replaced towards the west first by the Mixedgrass Plains and the Sand-Sage Grassland, and then by the Shortgrass Plains which occupy the Panhandle.

Fig. 1.—Population density of the genus *Culicoides* in Oklahoma.

The prevailing situation in the study of these biotic associations, is that no straight line of demarcation could be drawn between an association and the neighboring one. On the contrary, each association extends, where the habitat is suitable, in the form of pockets or islands into the neighboring association. This intercalation among the different biotic associations results in a considerable complication when the ecological affinities of animals are under investigation.

In this work the collections were made by using light-traps. Such a trap located in a narrow island or at the border of an association will probably contain insects of more than one source. Another factor that might contribute to this complication is the artificial introduction of semi-forest conditions by man through the grassland and of clearings in the forest. A good deal of care, therefore, should be used in interpreting the collection, and, in binding a species to any biological association the general distribution of that species should be analyzed.

BIOTIC ASSOCIATIONS AND THE COLLECTING STATIONS

The classification of the stations is according to the game-type map of Duck and Fletcher (1943). These stations are indicated in fig. 1.

The Oak-Pine Forest.—Station represented: Broken Bow (McCurtain Co.).

The Oak-Hickory Forest.—Stations represented: Jay (Delaware Co.); Stilwell (Adair Co.); Antlers (Pushmataha Co.). The last named station has pine elements and therefore it is also related to the Oak-Pine association.

The Postoak-Blackjack Forest.—Stations represented: Sapulpa (Creek Co.); Chandler (Lincoln Co.); Weleetka (Okfuskee Co.); Lake Texoma (Marshall Co.); Eufaula (McIntosh Co.) is close to the Oak-Hickory Forest; Poteau (LeFlore Co.) is close to the Oak-Pine Forest; while Medicine Park (Comanche Co.), Wichita Refuge (Comanche Co.), Lake Murray (Carter Co.), Stillwater (Payne Co.), Platt (Murray Co.), Pawnee (Pawnee Co.), Seminole (Seminole Co.), Guthrie (Logan Co.) are close to the grassland, especially the Tallgrass Prairie.

The Tallgrass Prairie.—Stations represented: Fairview (Major Co.); Kingfisher (Kingfisher Co.); Marietta (Love Co.); Norman (Cleveland Co.); Nowata (Nowata Co.); Perry (Noble Co.); Waurika (Jefferson Co.); Taloga (Dewey Co.); Pond Creek (Grant

Co.); Alva (Woods Co.); Clinton (Custer Co.); Ft. Reno (Canadian Co.); while Anadarko (Caddo Co.) and Overholser (Oklahoma Co.) are close to the Postoak-Blackjack Forest.

The Mixedgrass Plains.—Stations represented: Altus (Jackson Co.); Hobart (Kiowa Co.); Hollis (Harmon Co.); while Elk City (Beckham Co.) is close to the Tallgrass and to the Shinnery Oak-Grassland.

The Sand-Sage Grassland (mixed grass on sand dunes).—Stations represented: Shattuck (Ellis Co.); Doby Springs (Harper Co.); Mangum (Greer Co.) is close to the mesquite grassland.

The Shortgrass Plains.—Stations represented: Boise City (Cimarron Co.); Goodwell (Texas Co.) is somewhat close to the Sand-Sage Grassland.

In studying the seasonal incidence of these gnats, it is highly important to learn the approximate limits of the season of activity at various points in the state. The criteria available are the averages of the frost-free period. In the south, the frost lasts to a date that varies from about March 23 in the east to about March 26 in the middle and to about March 29 in the west. In the middle of the state the frost lasts to about April 3. In the northern part of the state the frost lasts to a date that varies from about April 6 in the east to about April 10 at the inner edge of the Panhandle and to April 20 at the extreme west. The Wichita Mountains are more like the midnorth in this regard.

In the northern part of the state, the frost begins about October 21 in the Panhandle and October 28 in the east. The Wichita Mountains area in this respect is more like the northeast. In the middle of the state the frost begins about November 2. In the southern part of the state the frost begins about November 9. The mid-north is more like the middle of the state or the south. However, it should be pointed out that in spite of the four-directional gradient in the frosting dates, it is not infrequent to find important differences in the dates given even for neighboring counties.

To summarize the previous data, it seems that the unfavorable season ends at an earlier date in the south, followed by the middle and then the north and Wichita Mountains. There is also minor westward delay of the spring.

The growing season ends in succession about opposite to its beginning: the Panhandle, the northeast and Wichita Mountains, the middle of the state (and the mid-north) and finally the southern part of the state (and the middle north).

The effect of these differences in the frost dates on the seasonal incidence of the genus and its components will be discussed later.

When referring to the biotic communities outside of Oklahoma the writer followed mainly the terminology of Transeau et al. (1940).

OKLAHOMA CULICOIDES

The genus is represented in Oklahoma by specimens of 23 species and subspecies, including the new subspecies, *C. piliferus riggsi.* It was also possible to distinguish the female of *C. v. oklahomensis,* which is described in this work.

The species collected in Oklahoma are arranged according to their abundance as follows:

	Specimens collected	Percentage of males
C. hieroglyphicus	31,546 (2,892)**	9.2 ± .2*
C. variipennis	28,407 (3,935)	13.8 ± .2
C. weesei	6,392 (1,082)	16.9 ± .5
C. crepuscularis	6,275 (1,099)	17.5 ± .5
C. haematopotus	4,638 (926)	20.0 ± .6
C. multipunctatus	3,770 (677)	18.0 ± .6
C. stellifer	2,725 (283)	10.4 ± .6
C. arboricola	878 (172)	19.6 ± 1.3
C. ousairani	832 (204)	24.5 ± 1.4
C. biguttatus	522 (25)	4.8 ± .9
C. travisi	245 (26)	10.6 ± 2.0
C. venustus	237 (9)	3.8 ± 1.2
C. spinosus	144 (17)	11.8 ± 2.7
C. nanus	127 (2)	1.6 ± 1.1
C. guttipennis	117 (19)	16.2 ± 3.4
C. piliferus riggsi	94 (11)	11.7 ± 3.3
C. salihi	71 (12)	.....
C. villosipennis oklahomensis	52 (14)	.....
C. obsoletus	44 (1)	.....
C. villosipennis	38 (5)	.....
C. hinmani	15 (5)	.....
C. baueri	5 (1)	.....
C. jamesi	2 (2)	.....
Total	87,174 (11,417)	13.1 ± .1

* Standard error.
** The numbers in parentheses represent the number of males.

KEY TO THE SPECIES OF CULICOIDES OF OKLAHOMA, PRIMARILY BY EXTERNAL CHARACTERS

1. Wings spotted with at least two light spots 6
   Wings without light spots 2
2. With a distinct mesonotal pattern, either dotted or striped type. Dark forms 3
   Without a distinct mesonotal pattern. Light forms 5
3. With a striped mesonotal pattern. Male genitalia distinctly large. Knees not light 4
   With a dotted mesonotal pattern imposed on striped pruinose areas. Male genitalia distinctly small. Knees light because of basal tibial light bands ......*C. multipunctatus*
4. Mesonotal pattern not very distinct, the submedian longitudinal bands on thorax broken once transversely. (Very restricted species.) ....*C. jamesi*
   Mesonotal pattern distinct, the submedian longitudinal bands on thorax broken in two places transversely. Knees, especially of the first pair of legs, are well differentiated in darkness from the rest of the legs. Very widely distributed species ....*C. hieroglyphicus*
5. Species of moderate size. Knees not dark ....*C. weesei*
   Quite small species. Dark knees ....*C. salihi*
6. With a distinct mesonotal pattern 19
   Without a distinct mesonotal pattern 7
7. Light spot covers the second radial cell at least in part (not only vein R_{4+5}); macrotrichiae poorly represented ....*C. obsoletus*
   Light spot is beyond the second radial cell; it may touch vein R_{4+5} but never extends in the cell itself; macrotrichiae better represented 8
8. Beside the marginal light spots of the wing there are at least two other light areas in the interior 9
   Light spots are close to the margin of the wings; no spot in the interior or only one ..14
9. There is a spot either on vein M_1 or in cell M_1 near the base 10
   The light streak in the main, is not on such vein or cell although it may be associated with them ....*C. travisi*
10. One light spot on vein M_1; often in addition there is another one on vein M_2 11
    No light spot on vein M_1; there are usually two light spots in cell M_1 12
11. The light spots of the wing are distinct and definite; those on vein M_1 and vein M_2 are round and separate from each other ....*C. ousairani*
    The light spots of the wing are less distinct and less defined; that on vein M_1 and also the one on vein M_2 (when present) are more like short streaks; the two when well developed are touching ....*C. p. riggsi*
12. Very small, moderately dark species. Wing spots small and distinct, the light spot near the base of cell M_1 is actually the main part of a spot on vein M_2; the light spot just beyond the second radial cell is bilobed and extends behind the cell ....*C. hinmani*
    Larger and lighter colored species. Wing spots large and less distinct, two light spots in cell M_1, the light spot beyond the second radial cell is simple 13
13. Two light spots in axial succession near the tip of cell M_2, one rounded light spot near the middle of cell R_5 ....*C. crepuscularis*
    Less distinct single light spot near the tip of cell M_2, the light spot of cell R_5 when present is less distinct and less round and near the tip of that cell ....*C. spinosus*
14. Wings with only two light spots on the costal margin ....*C. biggutatus*
    There is at least light area in the anal cell in addition to the two costal spots 15
15. The light spots are found only near the margins of the wing 16
    A light spot or streak is found in the interior of the wing in addition to the marginal light spots 17
16. The light spots along the posterior margins of the wing are somewhat small, definite in outline although not very distinct ....*C. nanus*
    The light area in the anal cell, and also the other spots (when present) along the posterior margin of the wing are somewhat large but not distinct and not definite ..17
17. The anal cell is mostly light, except on the inner side near the middle 18
    The anal cell is mostly dark except near tip ....*C. travisi*
18. The wings and the general appearance are dark. There may be an indistinct and indefinite light spot on vein M_1 ....*C. p. riggsi*

The wings and the general appearance are light. There may be an indistinct and indefinite light spot near the base of cell M_1 .... *C. spinosus*

19. The major part of the second radial cell is covered by light spot .... *C. venustus*
 The light spot lies just beyond the second radial cell 20
20. Three light spots, in axial succession, lie in cell R_5 beyond the second radial cell 21
 Only two light spots, in axial succession, lie in cell R_5 beyond the second radial cell .. 22
21. One of the largest species. The mesonotal pattern is of the dotted-type .... *C. variipennis*
 Species of moderate size. The mesonotal pattern is of the striped-type .... *C. stellifer*
22. Dark species. Light spot on vein M_2 and frequently also on vein M_1, one light spot in cell M_1. The striped mesonotal pattern is usually very well developed 23
 Light species. No light spot on veins M_1 or M_2; the spots in cell M_1 (usually two) may be so large as to cross the limits of the cell and fuse with spots of adjacent cells. The mesonotal pattern usually not well developed .... *C. crepuscularis*
23. The light spot of cell R_5 lies at the tip of the cell .... *C. haematopotus*
 The light spot of cell R_5 lies in about the middle of the cell 24
24. Light spot on vein M_1 25
 No light spot on vein M_1 .... *C. baueri*
25. Crossvein light spot large and extends to or beyond the fold between veins M and Cu 26
 Crossvein light spot smaller and hardly extends beyond vein M posteriorly 28
26. Vein Cu_2 with light borders .... *C. arboricola*
 Vein Cu_2 without light borders 27
27. One of the largest species. The male genitalia distinctly larger than the average size. The base of the duct of the spermathecae thickly and conically sclerotized. The third segment of the palpi is little swollen, the sensory pit is shallow .... *C. guttipennis*
 Large species. The male genitalia of average size. The base of the duct of the spermathecae thinly and shortly sclerotized. The third segment of the palpi is relatively well swollen. The sensory pit is moderately deep .... *C. villosipennis oklahomensis*
28. One of the largest species. The mesonotal pattern very distinct. .... *C. villosipennis*
 Large species. The anterior part of the mesonotal pattern indistinct .... *C. ousairani*

KEY TO THE SPECIES OF CULICOIDES OF OKLAHOMA BY THE MALE GENITALIA

1. Harpes divided into a pair of structures 5
 Harpes single, not completely divided, composed basally of an arch 2
2. Tip of claspers not inflated. Tip of harpes divided or composed of two lobes, never single. Distal to the arch of the aedeagus there is bifurcate terminal portion or three branches 3
 Tip of claspers inflated. Tip of harpes single structure. Terminal portion of the aedeagus single without distinct furcation 4
3. Inner processes of basistyles poorly developed. Harpes beyond the arch divided into two slender terminations. Terminal portion of aedeagus composed of two branches .... *C. variipennis*
 Inner processes of basistyles strongly developed, with curved irregular serration. Arch of harpes bears two lobes. Arch of aedeagus bears two posterior projections about equal in length to the terminal portion .... *C. multipunctatus*
4. The posterior end of the arch of the harpes bearing a single slender projection. Tip of claspers foot-shaped .... *C. hieroglyphicus*
 The posterior end of the arch of the harpes does not bear slender projection. Tip of claspers more extended .... *C. jamesi*
5. Tip of harpes spinose 6
 Tip of harpes not spinose 11
6. Arch of aedeagus wide at tip and bearing a projection on each side of the terminal portion of the aedeagus 7
 Arch of aedeagus considerably narrower at the tip than the base and without posterior projections 9

7. The two posterior projections of the arch of the aedeagus are only a little shorter than the terminal portion. Inner processes of basistyles although well developed are not boathook-shaped .... *C. salihi*
The two posterior projections of the arch of the aedeagus are much smaller than the terminal portion. Inner processes of basistyles boathook-shaped 8
8. Stem of harpes bears a well differentiated small swelling near the tip. The terminal portion of the aedeagus long and truncate .... *C. haematopotus*
Stem of harpes bears no swelling near the tip. The terminal portion of the aedeagus relatively shorter. The boathook shape of the inner processes of basistyles is less pronounced .... *C. baueri*
9. The inner processes of basistyles slender and not boathook-shaped. Base of harpes well bent and terminating in foot-shaped end. The tip of harpes spinose and without much bend .... *C. spinosus*
The inner processes boathook-shaped. Base of harpes not much differentiated. The tip of harpes bent and spinose. 10
10. Stem of harpes with gradual swelling. The arch of the aedeagus inverted V-shaped. No spines on membrane ventral to the aedeagus .... *C. stellifer*
Stem of harpes without swelling. Arch of the aedeagus evenly arched and rounded at tip. Base of membrane ventral to the aedeagus spinose .... *C. piliferus riggsi*
11. Claspers markedly bent at about the middle 12
No such bending in the middle of claspers 13
12. The terminal portion of the aedeagus long; the arch evenly arched. Inner processes of basistyles stout. The ninth tergite not very indented. Stem of harpes swollen. Male genitalia very large .... *C. guttipennis*
The terminal portion of the aedeagus short; the top of the arch flattened. Inner processes of the basistyles slender. Ninth tergite deeply indented. No swelling on stem of harpes. Male genitalia of average size .... *C. weesei*
13. Membrane ventral to the aedeagus spinose 14
Membrane ventral to the aedeagus not spinose 15
14. Inner processes of the basistyles poorly developed. The harpes with swelling on the stem; the base foot-shaped; the tip tapering to a point .... *C. crepuscularis*
Inner processes of the basistyles well developed. Harpes angular; the tip and base stout .... *C. biguttatus*
15. Apicolateral processes of the ninth tergite absent or very short, knob-like, never elongate 16
Apicolateral processes elongate 17
16. Apicolateral processes absent. Tip of claspers swollen. Ninth sternite with a deep notch. Inner processes well developed .... *C. obsoletus*
Apicolateral processes present but not elongate. Tip of claspers not swollen. Ninth sternite normal. Inner processes not developed .... *C. venustus*
17. Inner processes of the basistyles better developed than the dorsal processes, remind the observer of the boathook-shaped type. Harpes with slender stem. The terminal portion of the aedeagus short .... *C. nanus*
The inner processes slender. Stem of harpes usually swollen. The terminal portion of the aedeagus long 18
18. The end of the terminal portion of the aedeagus truncate 19
The end of the terminal portion of the aedeagus rounded or pointed 20
19. The aedeagus with long terminal portion, the arch low and without a membrane joining the sides. Base of harpes nearly foot-shaped .... *C. travisi*
The aedeagus with relatively short terminal portion, the arch high and with a sclerotized membrane joining the sides at the top. Base of harpes rod-shaped .... *C. hinmani*
20. A sclerotized membrane joining the sides of the distal part of the arch of the aedeagus present. The tapering end of the harpes short .... *C. ousairani*
Sclerotized membrane not present. The tapering end of the harpes long 21
21. The tapering part of the terminal portion of the aedeagus stout and bearing two pairs of projections .... *C. villosipennis*
The tapering part of the terminal portion of the aedeagus is slender and without projections or with only one pair 22
22. One pair of projections near the tip of the terminal portion of the aedeagus .... *C. villosipennis oklahomensis*
No projections on the terminal portion of the aedeagus .... *C. arboricola*

KEY TO THE SPECIES OF CULICOIDES OF OKLAHOMA FOR CLEARED FEMALES

This key is an attempt to supply the investigator with a supplementary tool for the identification of the species of this genus. It must not be expected, in many instances, to be as efficient as the other two types of keys, especially outside of Oklahoma, because of the variability in the structures involved. Those structures are also easily lost through handling. In addition, erroneous observations and abnormalities are not infrequent when such structures are involved.

1. One or more sclerotized spermathecae 3
   No visible sclerotized spermathecae 2
2. Knees light on account of light basal tibial bands. Last five segments of antennal flagellum slightly shorter than first eight. Of the palpi, the third segment little longer than the second, the sensory pit large and shallow .... *C. multipunctatus*
   Knees, especially of the first pair of legs, darker than the rest of the leg; the light band is sub-basal. Last five segments of antennal flagellum not shorter than first eight. Of the palpi, the third segment about twice as long as the second, the sensory pit small and deep .... *C. hieroglyphicus*
   .... *C. jamesi*[2]
3. There is one large spermatheca 4
   There are two large spermathecae 5
4. Spermatheca in the shape of bent blind tube. Last five segments of antennal flagellum shorter than first eight. Palpi with large shallow sensory pit .... *C. variipennis*
   Spermatheca oval. Last five segments of antennal flagellum longer than first eight. Palpi with moderately deep sensory pit .... *C. crepuscularis*
5. Spermathecae markedly different in size 6
   Spermathecae about equal in size 7
6. Second segment of the palpi about half the third, third well swollen and with deep sensory pit .... *C. nanus*
   Second and third segments of the palpi subequal, third not well swollen, the pit shallow or only moderately deep .... *C. piliferus riggsi*
7. Ring present 11
   Ring absent 8
8. Knees dark 9
   Knees not dark .... *C. weesei*
9. Spermathecae small, spherical; base of duct sclerotized for moderate length. Last segment of the palpus longer than fourth .... *C. hinmani*
   Spermathecae large oval or subspherical, base of duct sclerotized for a short distance. Fifth and fourth segments of the palpus subequal 10
10. Third segment of the palpi moderately swollen. (Faint ring might be seen.).. *C. travisi*
    Third segment of the palpi well swollen .... *C. spinosus*
11. Knees light, tibiae with narrow basal band .... *C. venustus*
    Knees dark; there may be light band above and below 12
12. Base of duct sclerotized for a long distance (about 10 micra or more) 13
    Base of duct sclerotized for a much shorter distance 15
13. Last five segments of the antennal flagellum more than half longer than the first eight. The ring is thick and wide .... *C. haematopotus*
    Last five segments subequal or very little longer than the first eight. The ring is less conspicuous 14
14. Of the palpi, the third segment well swollen and with a deep sensory pit, the fifth longer than the fourth. Base of duct lightly sclerotized but for longer distance than any other Oklahoma species (18 micra) .... *C. salihi*
    Of the palpi, third segment less swollen and with a shallow sensory pit, the fourth and fifth subequal. Base of duct sclerotized for shorter distance .... *C. stellifer*
15. The second segment of palpi distinctly longer than the third .... *C. arboricola*
    Second is subequal or shorter than third 16
16. Spermathecae spherical 17
    Spermathecae subspherical or oval 18

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[2] Female material of *C. jamesi* was not available for study and thus not differentiated in this key.

17. Last five segments of the antennal flagellum more than one-third longer than first eight. Of the palpi, the third segment little swollen and with shallow pit, the fourth and fifth subequal. Base of duct of spermathecae conically sclerotized .... *C. guttipennis*
Last five segments of the antennal flagellum subequal to the first eight. Of the palpi, the third segment moderately swollen and with a deep pit, the fourth considerably longer than the fifth. Base of duct of spermathecae not conically sclerotized .... *C. ousairani*
18. The second segment of the palpi markedly shorter than the third .... *C. baueri*
The second and third segments subequal 19
19. Last five segments of the antennal flagellum one-third or more longer than the first eight 20
Last five segments about equal to the first eight 21
20. Spermathecae relatively small. Third segment of the palpi slightly swollen .... *C. villosipennis*
Spermathecae of average size. Third segment of the palpi well swollen .... *C. v. oklahomensis*
21. Darkness of knees not easily distinguished. Small spermathecae. Third segment of the palpi with very small sensory pit .... *C. obsoletus*
Knees dark. Spermathecae of average size. Third segment of the palpi with shallow pit 22
22. Base of duct of spermathecae conically sclerotized .... *C. biguttatus*
Base of duct of spermathecae lightly and simply sclerotized .... *C. travisi*

In the description of the species in this manuscript some differences may be noticed from those reported by other authors. Such differences may represent true geographical variations or may only reflect differences in observations or in preparation of the material for study.

Treatment of the Species

Subgenus MONOCULICOIDES Khalaf

CULICOIDES CREPUSCULARIS Malloch

Diagnosis.—A somewhat light-colored, rather large species. The last five segments of the antennal flagellum are about one-third longer than the first eight. The second segment of the palpi is shorter than the third; the third is moderately swollen with a moderately deep sensory pit; the last two segments are subequal. There is a striped mesonotal pattern which is sometimes indistinct. The knees are dark.

There is a single, large, oval spermatheca; the base of the duct is sclerotized for a short distance; one or two very tiny rudimentary spermathecae sometimes present; no ring is present. The rudiment was observed in specimens from Perry, Wichita Refuge, Chandler, Eufaula, Norman, Shattuck, Hollis, and Elk City.

Of the wing light spots; one round spot near the middle of cell R_5 and two in axial succession in cell M_1.

In the male hypopygium, the membrane ventral to the aedeagus is spiculate; the harpes have foot-shaped base; the inner processes of the basistyles are not developed.

This species is very similar to *C. alaskensis* Wirth which is not found in Oklahoma. The latter species, apparently, differs from *C. crepuscularis* only in possessing two light wing spots. Reduction of the wing maculation is not

an infrequent phenomenon in *C. crepuscularis* in Oklahoma. Even with the constancy of reduced maculation, *C. alaskensis* should probably not occupy more than subspecific status.

Distribution and population density (fig. 2).—*C. crepuscularis* is one of the relatively unrestricted species in Oklahoma. It is well represented in the eastern deciduous forest and rare in the shortgrass and mixedgrass plains.

Outside of Oklahoma this species is found in almost every association. It has been reported from the coniferous forests of the Pacific coast and the Rocky Mountains, the chaparral, the bunch-grass, the creosote bush, the juniper, the shortgrass, the tallgrass, and the eastern deciduous forest.

Seasonal incidence.—One of the earliest species to appear, especially in the south. It is also moderately persistent at the end of the season.

In the south, it becomes well represented by the end of March, with some delay westward. The highest incidence is in April and might extend to May.

In the latitude of central Oklahoma, this species appears in the latter part of April or, especially in the west, in the first part of May.

In the northern part of the state and in the Wichita Mountains, it appears at about mid-May. The high incidence in mid and north Oklahoma is in June and may extend to a later date but is usually before August.

There is very much irregularity in the time of disappearance in the different parts of the state. The species should be expected as late as October. In most of the locations, however, it disappears earlier.

Outside of Oklahoma, the species is reported in northern Colorado from mid-May to mid-September and in California from April to October.

The proportion of males of this species in Oklahoma was 17.5% which is relatively high, with station variations of 2.9% to 51%. A significantly high male proportion was encountered in Wichita Refuge, Waurika, Overholser, and Shattuck.

CULICOIDES VARIIPENNIS (Coquillett)

Diagnosis.—This belongs to the *nubeculosus* group. It is one of the largest species and of dark coloration. The last five segments of the antennal flagellum are shorter than the first eight. The second segment of the palpi is shorter than the third; the third segment is moderately swollen and with a large shallow sensory pit; the fifth segment is longer than the fourth. The mesonotal pattern is of the dotted-type. The knees are dark. There is a single elongated, bent spermatheca.

Among the light spots of the wing, there are three in cell R_5 beyond the second radial cell; and two in the apical half of cell M_1. These last two spots may fuse with each other.

In the male hypopygium, the inner processes of the basistyles are poorly developed; the harpes are not divided completely; the terminal portion of the aedeagus is forked at the tip.

Distribution and population density (fig. 3).—This is a widely distributed species. It was found in almost all the stations that were studied although it seems to be rare in the oak-hickory and oak-pine forests. It was abundant in Elk City, Clinton, Fairview, Nowata, and Seminole.

Outside of Oklahoma the species also seems to be more xeric in affinity although it has been reported from the Pacific coast coniferous forest, the eastern deciduous forest, and the southern pine forest. Otherwise, the species is found associated with the desert-shrub vegetation, the bunch-grass, the chaparral, the tallgrass, the shortgrass, and the juniper.

Seasonal incidence.—Except in the south, this is one of the earliest species to appear. It is also persistent to the end of the season.

The species appears in the south in about the beginning of April.

In the north, it appears in about mid-May. The time of appearance in the Panhandle was very much earlier than expected.

In the latitude of central Oklahoma, it seems to appear at about mid-April. However, there seems to be much variation. Late appearance accompanied lower density than expected in stations such as Kingfisher.

The species may persist through part of October. High incidence occurred as early as May, but it may be encountered as late as early October.

Outside of Oklahoma, incidence reports include the following: California, February and from April to October; northern Colorado, end of May to the end of August; Maryland, mid-May through October; Kansas, April through June; Mexico, February, March, June, and October.

The proportion of males of this species in Oklahoma was 13.8% with station variation of 1.2% to 51.3%. Low male proportion was found in Hollis, Elk City, Taloga, Fairview, Wichita Refuge, and Weleetka, and high proportion in Goodwell.

Subgenus CULICOIDES

CULICOIDES VENUSTUS Hoffman

Description.—One of the largest species and of dark coloration. The last five segments of the antennal flagellum are somewhat longer than the first eight. The second segment of the palpi is about equal to the third; the third segment is slightly swollen, with a small shallow sensory pit far from the tip; the fifth segment is longer than the fourth. The mesonotum is dark brown with grayish pubescence forming striped pattern as illustrated by Hoffman (1925). Legs are brown. The knees are lighter in coloration than the darker legs on account of the presence of the narrow light band at the bases of the tibiae.

There are two spherical spermathecae, each about 45 micra in diameter; the base of the duct is sclerotized for a moderate distance; a rudimentary spermatheca and ring are present.

Among the wing light spots there is one on the second radial cell and in the middle of cell R_5. The rest of the maculation is closely similar to that illustrated by Hoffman (1925) for *C. venustus,* and by Fox and Hoffman (1944) for *C. inamollae,* except for the presence of two light spots, in axial succession, beyond the middle of cell M_1. The spot at the apex of that cell, in the collection of the same station and on the same day, is sometimes very small, faint, or absent. This is noticed in Antlers, Stilwell, Broken Bow, Eufaula, and Seminole.

In the male hypopygium, the inner processes are not developed; the harpes

are divided, wide at the base and slender at the tip; the arch of the aedeagus with a peg near the tip and sclerotized band near the base. The apicolateral processes are small.

In spite of these differences in the wing maculation and also in the antennae, the palpi, and the legs from the described *C. venustus*, the Oklahoma form was compared with type material of the species by Dr. Willis W. Wirth, who found that such variations were represented in that material.

There are quite a number of Neotropical species, some of which differ very little from each other and from *C. venustus*. They all fall in the *venustus* group. The present tendency of many authors is toward the lumping of many of these species, although the agreement on the synonymy is lacking. This group seems to be of Neotropical origin and of relatively recent dispersion to the north and many of the variations are probably no more than features of subspecies or intergrades.

Distribution and population density (fig. 4).—This is a restricted species. It is found as an occasional species in the eastern deciduous forest, and the density is lower in the postoak-blackjack forest. It is not found in the mixed, the short, and the sand-sage grassland.

Outside Oklahoma, it has been reported from the eastern deciduous forest.

Seasonal incidence.—This species, in the south, appears and attains high incidence early in April. In the north it seems to appear at the end of April, and it attains high incidence in June. It does not seem to be restricted in the season, although it is almost absent after the first part of August.

The proportion of males of this species in Oklahoma was 3.8% which is low.

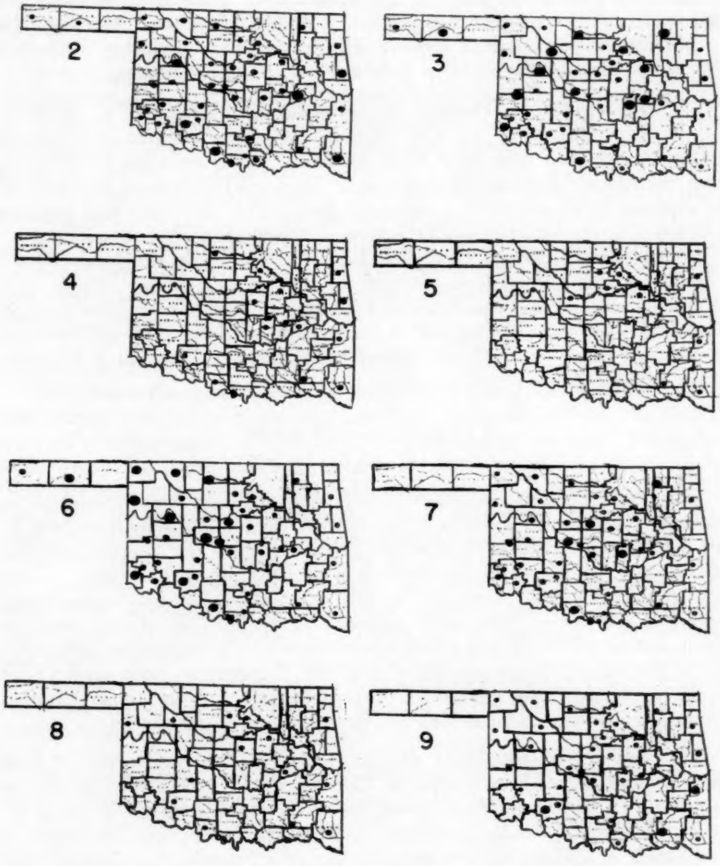
CULICOIDES OBSOLETUS (Meigen)

Diagnosis.—This has been placed tentatively within the *chiopterus* group. It is a small, lightly colored species. The last five segments of the antennal flagellum are little longer than the first eight. The second segment of the palpi is somewhat longer than the third; the third is hardly swollen and with a very small sensory pit; the fifth is slightly longer than the fourth. There is no distinct mesonotal pattern. The darkness of the knees is sometimes not easily distinguishable; there is also a faint, light, narrow band above and below.

There are two small spermathecae, oval to subspherical in shape. A rudimentary spermatheca and a small ring are present. The base of the duct is thickly sclerotized.

In the wing, the macrotrichiae are rare except at the tip of the wing, the light spots are large, diffuse, and faint. They are arranged as follows: one covers, partially, the second radial cell; one is at the apex of cell R_5; two elongated ones occur in cell M_1; one is at the tip of each of cells M_2, Cu_1, and anal cell; one at the base of the wing and the anal cell; and a light streak in cell M in front of the forking of vein Cu.

In the male hypopygium, there is a deep median pit in the ninth sternite; the inner processes of the basistyles are well developed; the tip of the clasper is swollen; the apicolateral processes are not developed.



Figs. 2-9.—Distribution and population density of *Culicoides* in Oklahoma. 2. *C. crepuscularis;* 3. *C. variipennis;* 4. *C. venustus;* 5. *C. obsoletus;* 6. *C. hieroglyphicus;* 7. *C. multipunctatus;* 8. *C. piliferus riggsi;* 9. *C. stellifer.*

Distribution and population density (fig. 5).—In Oklahoma this species is a restricted one. It was found in nine stations of the eastern deciduous forest, and here it was always rare. Apparently, Oklahoma does not furnish a favorable habitat for this species.

Outside of the state it has been found in the Pacific coast coniferous forest, the eastern deciduous forest, and the southern pine forest and has also been collected from short and tallgrass. In Scotland it is found in both woodland and open country with strong preference for pasture or cultivated

ground. In Oklahoma, however, it does not seem to be associated with the grassland. This species is also present in Alaska often as a coastal species and in Europe. It breeds in mouldy soil, running water, decaying vegetation, dry decaying fungi, damp debris from tree-holes, and sheep dung.

Seasonal incidence.—The high degree of habitat tolerance of *C. obsoletus* is not only reflected in its wide geographical range but also in the wide seasonal range. In spite of the low incidence, it was collected in this state from the end of March to late September. Such a widely spread species could be expected to be seasonally persistent. In addition, the latitudinal gradient between different localities as to the time of appearance is less prominent.

Outside of Oklahoma, the species has been reported in the summer from Canada, Alaska and various parts of the United States. In Illinois it is known to occur as early as April and as late as November; in Maryland in May and October. In England it occurs from mid-April to mid-October; in Scotland chiefly in the latter half of the summer; in Belgium it is known from April to June.

Subgenus SELFIA Khalaf

CULICOIDES HIEROGLYPHICUS Malloch

Diagnosis.—It is moderate in size and color. The last five segments of the antennal flagellum are about equal to the first eight. The second segment of the palpi is about half as long as the third; the third is moderately swollen with a small deep sensory pit; the fifth is no longer than the fourth. There is a striped mesonotal pattern. The submedian stripes are interrupted transversely in two places. The knees, especially of the first pair of legs, are dark. There are no distinctly sclerotized spermathecae. The wings are unspotted.

In the male hypopygium, the tips of the claspers are foot-shaped. The ninth sternite has two submedian projections with a deep, narrow, median notch. The harpes are undivided and have a slender distal portion.

Distribution and population density (fig. 6).—This species was encountered in practically all the stations in Oklahoma. It is usually found in low density in the eastern deciduous forest, and abundant or common in the grassland. The highest density was found in Shattuck, Taloga, and Ft. Reno.

Outside of Oklahoma, it is reported from the following associations: tallgrass, shortgrass, bunchgrass, chaparral, desert shrub, and juniper. It has also been reported from the eastern deciduous forest.

Seasonal incidence.—*C. hieroglyphicus* is one of the earliest appearing species (except in the south where there is some relative delay). It is also one of the most persistent species. Because of being rare in the east, and of the marked variation in density among the various stations the result of comparison is not very obvious.

This species shows an amount of variation in the time of appearance which obscures the expected time sequence. In the south, the species seems to appear early in April; in Altus it appeared at the beginning of April in spite of a higher expected density. In the latitude of central Oklahoma, the time of appearance is near mid-April; earlier appearance in Taloga and

Ft. Reno is accompanied by higher densities than expected, while later appearance in Norman, Clinton, and Elk City accompanied lower densities than expected. In the north the time of appearance is at about the end of April or later; earlier appearance in Alva is probably the result of favorable local weather at such time. The high density may occur in the south as early as April, in the latitude of central Oklahoma as early as May, and in the north in June. But anywhere in the state high incidence may be encountered as late as October.

Outside of Oklahoma incidence reports include: California, April to mid-October; northern Colorado, mid-May to mid-September.

The percentage of males of this species in Oklahoma was 9.2, which is somewhat low, and with station variations of 2% to 36.2%. High male proportion was encountered in Norman and Hollis, while low proportion was found in Taloga.

CULICOIDES JAMESI Fox

Diagnosis.—No females of this species were found in this study. It is moderate in size and color and very similar to *C. hieroglyphicus*. The knees are poorly differentiated in their color from the rest of the legs. The mesonotal pattern is striped. The wings are unmarked.

In the male hypopygium, the tips of the claspers are highly inflated. The harpes are not divided and without a long tapering tip. The sternite has a narrow deep median cleft. The aedeagus seems to have primitive form.

Distribution and population density.—In Oklahoma *C. jamesi* was very restricted in its range. It was present in only two stations, Goodwell and Nowata, both of which are in the grassland and in the north. Even in these two localities, it was rare.

Outside of Oklahoma, it has been reported from the coniferous forest of the Rocky Mountains and the Pacific Coast as well as the bunchgrass, and the intermountain sagebrush associations.

Seasonal incidence.—It has been collected in Oklahoma in May and June. In California it was reported from March to October.

CULICOIDES MULTIPUNCTATUS Malloch

Diagnosis.—This is a rather small, moderately colored species. The last five segments of the antennal flagellum are slightly shorter than the first eight. The third segment of the palpi is longer than the second, moderately swollen, and with a large shallow sensory pit; the fifth segment is slightly longer than the fourth. The mesonotal pattern is composed of numerous dots. The tibiae have light basal bands which give the knees a light coloration. There are no distinct sclerotized spermathecae. The wings are unspotted.

The male genitalia are distinctly smaller than the average in size. The processes of the basistyles are exceptionally well developed, the inner processes have irregular curved serration. The posterior end of the arch of the aedeagus bears two projections of about the same length as the terminal portion. There

is a membrane associated with the aedeagus which is well sclerotized. The harpes are undivided; the tip of their arch bears two lobes.

Distribution and population density (fig. 7).—*C. multipunctatus* is widely distributed in Oklahoma although never abundant. It was found in most of the stations, with the exception of those in the shortgrass plains. It was never common in the sand-sage and the mixed grassland or the eastern deciduous forest collections. It is more a species of the tallgrass and its transitional regions with the postoak-blackjack forest.

Outside of Oklahoma, this species is reported from the tallgrass prairie.

Seasonal incidence.—Among the early appearing species, *C. multipunctatus* was somewhat late in the time of appearance. It is also less persistent than most of the persistent species.

In the south it appears in the beginning of April, with some westward delay. The high incidence may be attained as early as April.

In the latitude of central Oklahoma the time of appearance seems to be late in April, with westward delay. In Norman the delay in appearance was accompanied by lower density than expected.

In the north, the time of appearance may be delayed much more. But both in central Oklahoma and in the north, the high incidence may be attained in June or delayed as late as October.

This species may persist as late as the latter part of October, but it usually disappears considerably earlier, perhaps as early as July or August.

The proportion of males of this species in Oklahoma was 18%, which is relatively high, and with station variations of 5.1% to 42.8%. These station variations do not seem statistically significant.

Subgenus OECACTA (Poey)

Culicoides piliferus riggsi new subspecies

Description.—This subspecies belongs to the *albicans* group and it is closely allied to both *C. piliferus* Root and Hoff. and *C. unicolor* (Coq.). It is of moderate size. In some localities (e.g. Jay) it was dark in coloration, but in other localities it may be light and thus it becomes easily confused with such species as *C. spinosus*.

Female.—The eyes are separate. The last five segments of the antennal flagellum are about as long as the first eight. The second segment of the palpi is about equal in length to the third; the third segment is moderately swollen and with shallow to moderate sensory pit; the fifth segment is equal or sometimes longer than the fourth.

The mesonotum is dark brown. There is a dark, narrow, central vitta; a wide, submedian gray pubescent stripe on each side of the central vitta; these two vittae are wider in the prescutellar region where each has a dark center. Grayish pruinescence is also present on the lateral borders of the mesonotum. The narrowness of the central vitta and the wideness of the pruinescence render the mesonotal pattern into indistinct type. The knees are dark, with light band above and below.

There are two subspherical spermathecae. These are always markedly

different in size. A rudimentary spermatheca and ring are present; the first in rare cases is bulbous in shape and well developed. The base of the duct is sclerotized to a short distance.

The wing macrotrichiae are well represented and distributed; the second radial cell is included in a dark spot; the light spots are not very distinct or definite and there are various degrees of reduction in their number. Those possessing the full set have the following light spots: just beyond the second radial cell; small one on the crossvein; large oval one at the tip of cell R_5, separated narrowly (by less than its length) from the spot located just beyond the second radial cell; on each of veins M_1 and M_2, opposite each other and united in the cell in between; at the tip of each of cells M_1, M_2, and Cu_1; at the tip of the anal cell; at the base of the anal cell; these two anal spots are connected near the margin, and the anal cell, accordingly, appears light in color except near the middle towards the interior of the wing. There is also a light streak in cell M in front of vein Cu.

In many localities, as in Antlers, Eufaula, and Broken Bow, specimens are encountered in which the light spots in cell R_5 and on veins M_1 and M_2 are reduced. The wing becomes more like that of *C. haematopotus*. However, the indefiniteness of the spots, the oval shape of the spot at tip of cell R_5, the absence of the mesonotal pattern, the dark color of the wing and the body distinguish *C. p. riggsi* readily from the above mentioned species. When the color is faded, and especially if such condition is accompanied by reduced maculation, the species may be confused with *C. spinosus*. However, the oval shape of the spot at the tip of cell R_5, or the mere presence of a trace of spot on vein M_1 (which is usually more persistent than the spot on vein M_2) distinguish *C. p. riggsi* from *C. spinosus*.

Occasionally, specimens may be encountered which possess only the two coastal light spots and the characteristic maculation of the anal cell. If the coloration in such cases has faded, the subspecies will be confused with *C. spinosus* (also of reduced maculation) and other superficially similar species. A sure way of identifying the subspecies in such case is to resort to the characteristic spermathecae, or to the male genitalia when available.

A discolored specimen of this subspecies as is encountered in the collection of Eufaula may even be confused with some *C. crepuscularis*, but careful analysis even of the dry specimen alone would give the insect its proper taxonomic status.

The male genitalia are closely similar to those of *C. unicolor*. However, the arch of the aedeagus is not as high and slender as in the later species; the terminal portion (more like that of *C. piliferus*) does not seem to be conical, but rather of the same width throughout. The end is truncate and has minute grooves as is the case with the tip of the aedeagus of *C. haematopotus*. Proximally, the inner processes of the basistyles are more slender, while the boathook-shape is well pronounced. The spines at the tip of the harpes are delicate and are easily lost. There are few spines at the base of the membrane ventral to the aedeagus, especially on the sides. Spines are not developed either in the group to which this subspecies belongs (*albicans* group), or in the whole *haematopotus* complex, with the exception of *C. albicans*, a European species to which *C. p. riggsi* is closely similar. These

curious spines therefore are a new development along the line of evolution of this complex.

Before closing the discussion of this subspecies it would be beneficial to summarize the differences from the two allied forms, *C. unicolor* and *C. p. piliferus*. The first of these two species with its variations has been redescribed by Wirth (1951, 1952). In the first instance it would seem that this subspecies would be just a variant of *C. unicolor,* fitting the so-called "well marked phase" of Wirth. There is considerable similarity between the two forms in the wing, the antennae, the palpi, and the mesonotum. The difference in the size of the two spermathecae and the dark knees are not reported; they are not to be regarded as variables on the basis of correspondence with Dr. Willis W. Wirth, who pointed out that they might be the same in the type material. The differences from *C. unicolor* appear to be mainly in the genitalia. The spiculated membrane, the inner processes of the basistyles, and the aedeagus differences have already been described. The first two differences differentiate the subspecies also from *C. p. piliferus*. The latter species is an eastern one, a matter that supplied other reason for connecting the new subspecies to *C. p. piliferus* and not to *C. unicolor*.

More information is needed on *C. unicolor* and *C. piliferus*. Rearing is now being carried on by Wirth (personal communication). Such work on the subspecies in Oklahoma is undoubtedly necessary to give a better picture of interrelations.

Holotype, male, Antlers (Okla.), April 4, 1946; allotype, female, Antlers (Okla.), March 29, 1946; about 30 paratypes, Antlers (Okla.), 1946; deposited in the University of Oklahoma Museum.

Distribution and population density (fig. 8).—It has relatively wide spotty distribution. It was found in 14 stations. It is not found in the mixed and the short grassland. The main association of this subspecies, in Oklahoma, is with the eastern deciduous forest, but even then it is never common. The highest density is found in the oak-pine forest.

Seasonal incidence.—In Oklahoma, this seems to be an early subspecies and with limited season. It is mainly represented in April, to a less extent in May, and rarely beyond that.

The proportion of males of this subspecies in Oklahoma was 11.7%.

CULICOIDES STELLIFER (Coquillett)

Diagnosis.—This belongs to the *furens* group. It is moderate in size and color. The last five segments of the antennal flagellum are about equal to the first eight. The second segment of the palpi is little shorter than the third; the third segment is slightly swollen with a broad shallow sensory pit; the last two segments are subequal. There is a striped mesonotal pattern. The knees are dark.

There are two oval spermathecae; the base of the duct is sclerotized for a long distance; a rudimentary spermatheca and a ring are present.

Among the light spots of the wing, there are three in cell R_5 beyond the second radial cell; and two such spots, in axial succession, in cell M_1 beyond the middle of the cell.

In the male hypopygium, the inner processes of the basistyles are boat-hook-shaped. The tip of the harpes is spinose while the stem has a gradual swelling. The aedeagus has inverted V-shaped arch.

Distribution and population density (fig. 9).—It is well distributed in the state, although it is never abundant in any locality and not found in the shortgrass and many of the mixedgrass plains stations. The species is better represented in the eastern deciduous forest, and is rare elsewhere.

Outside of Oklahoma this species is reported from the eastern deciduous forest, the northern transitional forest, the chaparral, the tallgrass prairie and also from the shortgrass plains. It is possibly present in some other xeric habitats.

Seasonal incidence.—Among the early appearing species, *C. stellifer* is intermediate except in the south where it is the last to appear.

In the north and the west the species is rare. In the middle of the state it seems to appear late in April or later. Earlier appearance in Poteau accompanies a higher density than expected.

In the Wichita Mountains Refuge and in somewhat northern localities, the appearance is in late May or later.

In the south the appearance is in April.

The high incidence is usually in June or July and the species is rarely represented beyond the first part of September.

The incidence in northern Colorado is reported from the end of June to about mid-September; in California from April to August; in Illinois and Michigan in the summer; and in New Mexico in November.

The proportion of males of this species in Oklahoma was 10.4%, which is a little low, and with station variations of 1.8% to 46.8%. The percentage in the Wichita Mountains Refuge is significantly high.

CULICOIDES SALIHI Khalaf

Diagnosis.—This belongs to the *haematopotus* group. It is rather small and of light coloration and superficially somewhat similar to *C. weesei.* The last five segments of the antennal flagellum are very little longer than the first eight; the last segment is considerably longer than each of the preceding four. The third segment of the palpi is longer than the second and well swollen with a small, deep sensory pit; the last segment is longer than the fourth. There is no mesonotal pattern. The knees are dark.

There are two oval, lightly sclerotized spermathecae; the base of the duct is sclerotized for a long distance, in fact longer than the base of the duct of any other species in Oklahoma; a rudimentary spermatheca and ring are present. The wings are unspotted.

In the male hypopygium, the inner processes of the basistyles are better developed than the dorsal and are approximate. The tip of the harpes is spinose. There is a posterior projection from the arch of the aedeagus on each side of the terminal portion; these two projections are shorter than the terminal portion and are convergent at the base.

Distribution and population density (fig. 10).—This species is found in

only five of the 41 stations, and even here it is found in low density. It does not seem to have affinity to the eastern deciduous forest or to the tallgrass prairie. Oklahoma does not seem to offer appropriate habitat to this species because even in the rest of the grassland it is either absent (as in the shortgrass plains) or its density is very low. Or, again, the light-traps were selective in their function.

Seasonal incidence.—The main incidence of this species occurred in June, July, and rarely later.

CULICOIDES BAUERI Hoffman

Diagnosis.—This is the second species belonging to the *haematopotus* group. It is dark and a rather large species. Superficially, it is closely similar to the members of the *villosipennis* group. The last five segments of the antennal flagellum are somewhat longer than first eight. The second segment of the palpi is much shorter than the third; the last two segments are subequal. The mesonotal pattern is of the striped type.

The two spermathecae are subspherical; the base of the duct is sclerotized for a moderate distance; a rudimentary spermatheca and ring are present.

Among the light spots of the wing, there are two just beyond the second radial cell; a cleaved one in about the middle of cell R_5; one in cell M_1; on vein M_2 in about the middle. There is no light spot on vein M_1.

In the male hypopygium there are a pair of posterior projections on the arch of the aedeagus. The harpes has a spinose tip but without swelling on the stem. The boathook-shaped inner processes of the basistyles are sometimes not well pronounced. The terminal portion of the aedeagus is shorter than that of *C. haematopotus*.

Distribution and population density.—This species has been found in Oklahoma in only two stations, Boise City and Jay, and in both of them it was rare. However, it should not be regarded as one of the restricted species for in this state one of the two stations was in the shortgrass plains while the other was in the oak-hickory forest. In addition, outside of Oklahoma, this species has been reported from such a wide variety of associations as the Pacific coast coniferous forest, the chaparral, the bunchgrass, the creosote bush, the shortgrass, and the eastern deciduous forest.

Seasonal incidence.—Such study on this species in Oklahoma is made impossible because of its extremely low incidence. It was collected in the latter half of May and also in August. Outside of Oklahoma, the incidence is reported in California from April to September; in northern Colorado from early June to early August; in Mexico from February to November.

CULICOIDES HAEMATOPOTUS Malloch

Diagnosis.—This is the third species in Oklahoma which belongs to the *haematopotus* group. It is moderate in size and color. The last five segments of the antennal flagellum are about one and one-half times the length of the first eight. The second segment of the palpi is about half as long as the third; the third is swollen with a broad shallow sensory pit; the fifth is longer

than the fourth. There is a striped mesonotal pattern. The knees are dark.

There are two oval spermathecae; the base of the duct is sclerotized for a relatively long distance; a rudimentary spermatheca and thick ring are present.

On the wing, there is a light spot at tip of cell R_5, which is separated by more than its length from the spot just after the second radial cell. In *C. piliferus riggsi,* the light spot at the tip of cell R_5 is separated by less than its length from the second radial light spot. Of the other wing spots, there is one near the apex of cell M_1 and an elongated one on each of veins M_1 and M_2. The spot on vein M_1 (unlike that of *C. p. riggsi*) is below the level of the proximal end of the spot on vein M_2.

In the male hypopygium, the inner processes of the basistyles are boathook-shaped; the tip of the harpes is spinose, the stem has a conspicuous lateral enlargement near the top; the arch of the aedeagus has one posterior projection on each side of the terminal portion, the terminal portion is long and truncate.

Distribution and population density (fig. 11).—This is a widely distributed species in Oklahoma. It was encountered in practically all the stations. However, it was not abundant anywhere and the density seems to be highly local. It was never more than "rare" in the shortgrass plains.

Outside of Oklahoma, the species also seems to be highly unrestricted. It has been reported from the Pacific coast coniferous forest, the chaparral, the bunchgrass, the creosote bush, the tallgrass, the shortgrass, the eastern deciduous forest, and the southern pine forest.

Seasonal incidence.—This is a rather early appearing species and also moderately persistent at the end of the season. In southern Oklahoma it appears as early as the beginning of April with some delay towards the west; the high incidence may be attained as early as April. In the latitude of central Oklahoma it appears in about mid-May, and attains high incidence in that month. In the north it usually appears beyond May with high incidence in June.

The species may be expected up to mid-October and high incidence may occur as late as October.

Outside Oklahoma, the incidence is reported in California in February and from April to September; in northern Colorado from about the end of May to mid-September; and in Mexico in March and April.

The proportion of males of this species in Oklahoma was 20% which is relatively high, and with station variations from 2.9% to 39.2%. The proportion in Anadarko and Doby Springs was significantly high.

CULICOIDES SPINOSUS Root and Hoffman

Diagnosis.—This is the only species in Oklahoma which belongs to the *spinosus* group. It is of moderate size and light coloration. It is superficially similar to *C. travisi* and sometimes to *C. p. riggsi.* The last five segments of the antennal flagellum are usually more than one-third longer than the first eight. Of the palpi, the third segment is usually longer than the second and all swollen with moderate pit; the last two segments are subequal. Specimens collected from Broken Bow show some difference in the ratios mentioned above. The antennal ratio seems to be lower, as is the ratio of the third seg-

ment of the palpi to the second. Such variations in these appendages, which are present sometimes even within the species limit, and which also bring together quite distantly related species, prevent the use of such structures for principal phylogenetic purposes. There is no distinct mesonotal pattern. The knees are dark.

There are two oval spermathecae which are usually larger than those of *C. travisi*. The base of the duct is sclerotized for a short distance. A rudimentary spermatheca is present, but there is no distinct ring. In Broken Bow, the reversion of the rudimentary spermatheca to the ancestral condition has been noticed.

In the wing, a large light spot is found beyond the second radial cell; on the crossvein and continuous with a narrow streak in front of vein Cu; in cell Cu_1; at tip of the anal cell, another one at the base while the middle of this cell is gray, so the anal cell is mostly light except in the middle of the cell towards the interior of the wing. Small light spot is found at tip of cells R_5, M_1, M_2. A streaklike light spot is found at the base of cell M_1 There is thus gradual reduction in the size of the spots from the anal cell towards the tip of the wing. The wing light spots are, like those of *C. travisi,* characterized by indistinctness and the reduction in the size of the light spots is also accompanied by increased indistinctness. For this reason the spot at the tip of cell M_1 and especially that at the tip of cell R_5 are usually not present. The fact that there is a light spot near the base of cell M_1 in this species and that the anal cell is mainly light in color differentiates it from *C. travisi.* The first mentioned characteristic serves also to differentiate it from *C. p. riggsi.*

In the male hypopygium, the harpes are somewhat angular and possess spinose tip.

Distribution and population density (fig. 12).—This species has not been found in the short or mixed grassland. It was best represented, although only occasionally, in the oak-pine association. The rest of the data on this species in Oklahoma indicates a wider possible distribution, although with low density, especially through the postoak-blackjack forest.

Outside of Oklahoma, it has been reported from the eastern deciduous forest.

Seasonal incidence.—The high incidence is expected to be earlier in the south, perhaps in April; and such incidence is delayed on proceeding northwestward. The proportion of males of this species in Oklahoma was 11.8%.

CULICOIDES BIGUTTATUS Coquillett

Diagnosis.—This is lightly colored and of moderate size. Superficially it is similar to *C. travisi.* The last five segments of the antennal flagellum are about equal to the first eight. Of the palpi, the second and third segments are subequal; the fourth and fifth subequal; the third is moderately to well swollen with shallow pit. There is no distinct mesonotal pattern. The knees are dark.

Two oval spermathecae are present; the base of the duct is thickly and conically sclerotized for moderate length; a rudimentary spermatheca and ring

are present. In a few specimens from the collection of Broken Bow, the rudimentary spermatheca was relatively excessively developed. The conical sclerotization of the base of the duct and the distinct ring distinguish the cleared female of this species from that of *C. travisi.*

In the wing, the macrotrichiae are better represented in this species than in *C. travisi.* There are two light spots; one is on the radio-median cross-vein and the other just beyond the second radial cell. These two spots usually stand in strong contrast in the dark wing.

In the male hypopygium, the membrane ventral to the aedeagus is spiculate. The harpes are stout and angular. The ninth tergite is deeply cleft.

Distribution and population density (fig. 13).—*C. biguttatus* is a restricted species in distribution in Oklahoma. It was present in 11 of the 41 stations. It was not represented in the north or west. It is common or occasional in the eastern deciduous forest and rare on the western borders of such forest. It has not been found north or west because of this association.

Outside of Oklahoma the species was reported from the eastern deciduous forest.

Seasonal incidence.—This is a somewhat early appearing species. In the southern part of the state it seems to appear early in April with the highest incidence in April or early May. In the latitude of central Oklahoma, the time of appearance is delayed to the second half of April with the high incidence in May. The species practically disappears near the end of May or early in June.

The proportion of males of this species in Oklahoma was 4.8% which is quite low.

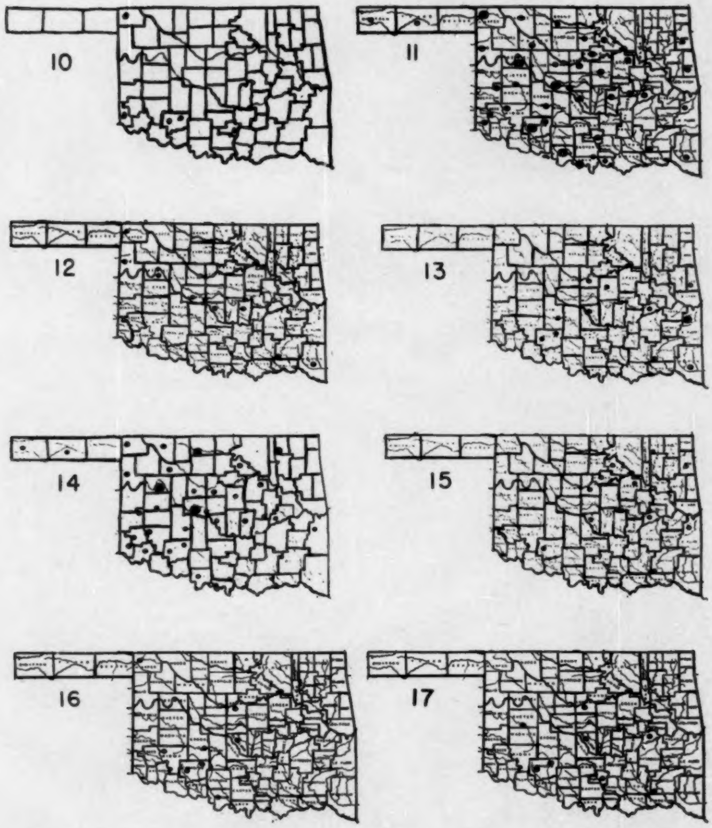
CULICOIDES WEESEI Khalaf

Diagnosis.—This species belongs to the *schultzei* group. It is moderate in size, light in color, and superficially similar to *C. salihi* and to *C. travisi.* The last five segments of the antennal flagellum are subequal to the first eight, the last segment is not much longer than each of the preceding. The third segment of the palpi is longer than the second and moderately swollen with a large shallow sensory pit; the last two segments are subequal. There is no distinct mesonotal pattern. The knees are not dark.

There are two oval spermathecae which are well sclerotized; the base of the duct is sclerotized for a moderate length; a rudimentary spermatheca is present; there is no distinct ring. The wings are unspotted.

In the male hypopygium, of the tergite, the apicolateral processes are conspicuously well developed; the membrane ventral to the aedeagus is spinose; the claspers are somewhat bent; the terminal portion of the aedeagus is short and truncate; the harpes are stout and angular.

Phylogenetically, this species is most closely allied to *C. stonei* James, a species not found in Oklahoma. The membrane ventral to the aedeagus in the latter species is not spinose; in addition the dorsal processes of the basistyles are better developed, the bending of the claspers is more pronounced and the terminal portion of the aedeagus is wider proximally near its junction with the arch. These differences are less than the average interspecific differences in



Figs. 10-17.—Distribution and population density of *Culicoides* in Oklahoma. 10. *C. salihi;* 11. *C. haematopotus;* 12. *C. spinosus;* 13. *C. biguttatus;* 14. *C. weesei;* 15. *C. guttipennis;* 16. *C. hinmani;* 17. *C. nanus.*

this genus. The ancestral form of these two species has the membrane ventral to the aedeagus spinose; and hence *C. weesei* seems to have better preserved the ancestral condition.

Distribution and population density (fig. 14).—This is a somewhat widely distributed species in Oklahoma. In the eastern deciduous forest, it was present only in the postoak-blackjack association and even then it was rare, probably as a grassland element. Such a low density was also found in the shortgrass plains. Usually there was a higher density in the rest of the grassland associations. It was abundant in Taloga and Ft. Reno.

Seasonal incidence.—Among the early appearing species, *C. weesei* seems

to lag behind in its appearance. Among the persistent species, it is also one of the earliest to disappear.

It is poorly represented in the south. In the latitude of central Oklahoma, it seems to appear near the end of April, and sometimes later. In the north, it appears in May or sometimes later. Unusual delay in the time of appearance in Alva was also accompanied by lower density than expected.

The high incidence occurred as early as May and as late as October, but was often in June or July and usually before the end of August. The species might be expected through part of October, although it often disappears earlier.

The proportion of males of this species in Oklahoma was 17% which is somewhat high, and with station variations between 0.0% and 31.2%. The percentage of males in Taloga was significantly low.

CULICOIDES GUTTIPENNIS (Coquillett)

Diagnosis.—It is dark-colored, one of the largest species, and superficially similar in appearance to the members of the *villosipennis* group. The last five segments of the antennal flagellum are little more than one-third larger than the first eight. Of the palpi, the second and third segments are subequal, the third is little swollen with a small shallow sensory pit, the last two segments are subequal. The mesonotal pattern is striped. The knees are dark.

There are two very well sclerotized spherical spermathecae; the base of the duct is conically sclerotized; a rudimentary spermatheca and a ring are present.

On the wings, among the light spots, a large one on the cross-vein, one in about the middle of cell R_5, one in about the middle of cell M_1, one on each of veins M_1 and M_2. Vein Cu_2 is without light borders.

The male hypopygium is very large. The claspers are bent. The membrane ventral to the aedeagus is spiculate. The harpes are stout and angular with massive base and bent tip. The aedeagus has a low arch.

Distribution and population density (fig. 15).—In Oklahoma this is one of the restricted species. It has been found only in 11 stations in the eastern deciduous forest. In all these stations the species was rare.

Outside of Oklahoma the species has also been found in the eastern deciduous forest, breeding in tree-holes.

Seasonal incidence.—It was not possible to study the incidence of this species in detail because of its rarity in the state. However, it has not been collected earlier than the end of April; it occurred mainly in the latter part of May, June, and July; it rarely occurred as late as October.

Reports from various parts of this country indicate incidence that extends from April to August.

The proportion of males of this species in Oklahoma was 16.2%.

CULICOIDES HINMANI Khalaf

Diagnosis.—This belongs to the *heliophilus* group. It is moderate in color and the smallest form of the genus in Oklahoma. The last five segments of the antennal flagellum are about one-third longer than the first eight. The third segment of the palpi is longer than the second; it is swollen and with

a moderately deep pit; the fifth segment is longer than the fourth. There is no distinct mesonotal pattern. The knees are dark.

There are two spherical spermathecae. The base of the duct is sclerotized for moderate length. A rudimentary spermatheca, but no ring, is present.

The wing macrotrichiae are rare inside the cells. Among the wing light spots, one just beyond the second radial cell is the same shape as that of *C. stellifer* but more constricted; one before the tip of cell R_5 is more or less rounded; one is before the tip of cell M_1; one on vein M_2 is interrupted by the vein, and the larger part of the spot is in cell M_1. The spot on vein M_2 seems sometimes independent from the vein.

In the male hypopygium there is a sclerotized membrane joining the sides of the arch of the aedeagus near the tip; the terminal portion of the aedeagus is truncate. Of the harpes, the base is shaped like a bent rod; the tip is pointed; the stem of additional material examined does not seem to be as swollen as that illustrated for the allotype (Khalaf 1952) and the tapering tip is longer and curved.

Distribution and population density (fig. 16).—In Oklahoma this species seems to be a restricted one. It was found in only eight stations, all in the grassland. Even then, the distribution was spotty and the species was rare and was not represented in the shortgrass plains.

Seasonal incidence.—This is a rare species in the stations in which it was present. It occurred mainly in June and July, rarely in May and September.

CULICOIDES NANUS Root and Hoffman

Diagnosis.—This is one of two species in Oklahoma that belong to the *pictipennis* group. It is rather small, lightly colored, and similar to *C. travisi.* The last five segments of the antennal flagellum are slightly longer than the first eight. The second segment of the palpi is about half as long as the third; the third is well swollen with a deep sensory pit; the fifth is slightly longer than the fourth. There is no distinct mesonotal pattern. The knees are dark.

There are two subspherical spermathecae. These are different in size. The base of the duct is sclerotized for only a short distance. A rudimentary spermatheca and ring are present.

In the wing, there are two distinct light spots; one is just beyond the second radial cell and another on the crossvein. Less distinct, but well defined light spots are present near the tips of the cells M_1, M_2, Cu_1, anal cell, and sometimes, especially in the male, at the end of cell R_5. A very light spot is present at the base of the anal cell and the base of the wing. There is no light spot within the interior of the wing. The more defined wing spots and the smaller size differentiate this species from *C. travisi.*

In the male hypopygium, the inner processes of the basistyles are very well developed; the harpes are slender; the terminal portion of the aedeagus is short.

Distribution and population density (fig. 17).—This is a restricted species.

It was found in only eight stations, and in no instance was it common or abundant.

Outside of Oklahoma this species is reported from the eastern deciduous forest, and breeding in tree-holes. In Oklahoma it is not present in the short, mixed, or sand-sage grassland. The spotty distribution of this species and the association mainly with the postoak-blackjack forest seems to be, at least in part, the result of the requirement of treeholes.

Seasonal incidence.—It rarely occurred before the end of May. It was usually found in June and July. The proportion of males of this species in Oklahoma was 1.6%, which is quite low.

CULICOIDES TRAVISI Vargas, 1949

Syn. *C. simulans* R. & H., 1937, nec *C. simulans* Vimmer, 1932.

Diagnosis.—This is the other species that belongs to the *pictipennis* group. It is of moderate size, light coloration, and superficially similar to *C. biguttatus* and *C. spinosus.* The last five segments of the antennal flagellum are little longer than the first eight. The second segment of the palpi is almost as long as the third; the third is moderately swollen and with a shallow sensory pit. The pit is larger and the third segment is more swollen than in *C. biguttatus.* There is no distinct mesonotal pattern. The knees are dark.

The two spermathecae are oval to subspherical; the base of the duct is only lightly sclerotized and for a short to moderate length; a rudimentary spermatheca and sometimes faint ring are present. Excessive clearing may prevent seeing the ring.

In the wing, there are two relatively distinct light spots, on the crossvein and beyond the second radial cell. These are usually larger than the comparable spots of *C. biguttatus.* The wing also differs from that of the latter species in the presence of faint and less definite light spots in the tip of cells R_5, M_1, M_2, Cu_1, and the anal. A short light streak may be present within the interior of the wing behind vein M and more rarely in front of this vein. The light spots at the tip of cell M_1 and more often at tip of cell R_5 are sometimes absent. Moreover, the spots are sometimes so light that the wing may appear unspotted, with only the two costal spots, or with the costal spots and a spot near the tip of the anal cell. The species in the reduced phase may be confused with *C. biguttatus* and *C. spinosus.* It might be confused with the latter species even when the maculation is not reduced. Without the examination of the male genitalia, *C. travisi* can be distinguished from *C. biguttatus* by the presence of the anal light area and by having the base of the duct not conically or thickly sclerotized; the spermathecae are also not as well sclerotized as those of *C. biguttatus.* It differs from *C. spinosus* in that the anal cell is mainly dark in color, while in *C. spinosus* it is mainly light.

In the male hypopygium, the aedeagus has a low arch and a long terminal portion.

Distribution and population density (fig. 18).—This species was encountered in about half of the stations that were studied. It was not found in

the mixed, short, and sandsage grassland. It was rare in the tallgrass prairie and sometimes a little higher in density in the eastern deciduous forest.

Outside of Oklahoma, this species is reported from part of the eastern deciduous forest. It has also been collected from Evergreen, Colorado (James 1943).

Seasonal incidence.—This is another seasonally restricted species and rather an early one. The main incidence in the north seems to occur in June, while in the middle and south it is earlier. It was rarely collected later than June.

The proportion of males of this species in Oklahoma was 10.6%.

CULICOIDES OUSAIRANI Khalaf

Diagnosis.—This is one of four forms in Oklahoma which belong to the *villosipennis group.* It is a rather large, dark-colored species, and superficially similar to the rest of the *villosipennis* group. The last five segments of the antennal flagellum are subequal with the first eight. The third segment of the palpi is somewhat longer than the second, moderately swollen with a small deep sensory pit. The fourth segment is considerably longer than the fifth. Of the mesonotal pattern only the prescutellar part of it is retained. The knees are dark.

There are two spherical spermathecae; the base of the duct is sclerotized for a short distance; a rudimentary spermatheca and ring are present.

In the wing, the light spots are small, very definite, and stand in clear contrast with the dark background. Of the light spots, a small one that does not extend beyond vein M is on the crossvein; one is in the middle of cell R_5; one is on each of veins M_1 and M_2; one is near the middle of cell M_1.

In the male hypopygium, the distal tapering part of the terminal portion of the aedeagus is relatively short while the proximal part is long; there is sclerotized membrane joining the sides of the distal part of the arch. The tapering end of the harpes, compared with that of the other members of the group, is relatively short.

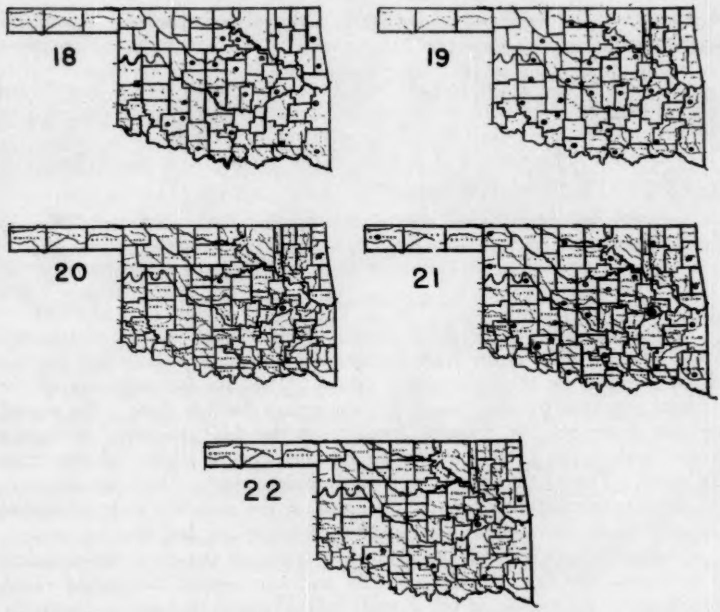
Distribution and population density (fig. 19).—This species is well distributed in the state, but never common or abundant. It is found usually in low density except in Waurika and Wichita Refuge where it is occasional. It has not been found in the mixed, short, and sand-sage grassland, and does not seem to be found in the oak-hickory association. It seems to be associated with the postoak-blackjack forest and with the tallgrass prairie.

Seasonal incidence.—In spite of the relatively poor representation of the species in this state, it still seems to appear in the south in April, and in more northern localities and the Wichita Mountains the species makes its appearance later. The seasonal activity for this species may continue through the major part of September. It is rarely present beyond this month.

The proportion of males of this species in Oklahoma was 24.5%, which is relatively high.

CULICOIDES VILLOSIPENNIS Root and Hoffman

Diagnosis.—This is the second species which belongs to the *villosipennis* group. It is one of the largest species, of dark coloration, and similar to the



Figs. 18-22.—Distribution and population density of *Culicoides* in Oklahoma. 18. *C. travisi;* 19; *C. ousairani;* 20. *C. villosipennis;* 21. *C. arboricola;* 22. *C. villosipennis oklahomensis.*

rest of the *villosipennis* group and also superficially to *C. guttipennis.* The last five segments of the antennal flagellum are little more than one-third longer than the first eight. The second segment of the palpi is about as long as the third; the third segment is slightly swollen with a moderate sensory pit; the last two segments are subequal. There is a striped mesonotal pattern. The knees are dark.

There are two oval to subspherical spermathecae which are relatively small; the base of the duct is sclerotized for a short distance; a rudimentary spermatheca and ring are present.

Among the light spots of the wings, there is a small one on the crossvein which hardly extends beyond vein M posteriorly; this spot in *C. guttipennis* is considerably larger. Another light spot is beyond the second radial cell, in about the middle of cell R_5, on vein M_1 near its base, in about the middle of cell M_1, in the middle of vein M_2. Vein Cu_2 is without light borders.

In the male hypopygium, the harpes have a long pointed tip; the terminal portion of the aedeagus is stouter than that of *C. arboricola,* and bears two pairs of projections which are stouter than the projections of *C. v. oklahomensis.* Sometimes the projections in some localities, as in Jay, are three in number or even two. Such conditions can be either artifact or of true phyletic

significance indicating hybridization with some other member of the *villosipennis* group.

Distribution and population density (fig. 20).—This species is restricted in Oklahoma to the eastern deciduous forest. It has been found only in four stations and was rare except in Eufaula where it was occasional.

Outside of Oklahoma it is present in the chestnut oak association, with tree-holes as the known breeding habitat.

Seasonal incidence.—This species was present from about mid-May to about the end of June. It was rarely represented beyond the latter month.

CULICOIDES ARBORICOLA Root and Hoffman

Diagnosis.—This is the third species which belongs to the *villosipennis* group. It is a dark, rather large species, and superficially similar to the rest of the members of the *villosipennis* group. The last five segments of the antennal flagellum are about one-third longer than the first eight. The second segment of the palpi is distinctly longer than the third; the third is slightly swollen with a small, shallow sensory pit; the fifth is slightly shorter than the fourth. The mesonotal pattern is of the striped type. The knees are dark.

The two spermathecae are oval; the base of the duct is simply sclerotized and only for a short length; a rudimentary spermatheca and ring are present.

Among the light spots of the wing, there is one on the cross-vein extending to or beyond the fold between veins M and Cu; beyond the second radial cell; in about the middle of cell R_5; on vein M_1 near its base; in about the middle of cell M_1; in about the middle of vein M_2. Vein Cu_2 is definitely with light borders.

In the male hypopygium, the terminal portion of the aedeagus is broad at the base, narrow at the tip.

Distribution and population density (fig. 21).—This species is well distributed in the state. It was present in 25 of the 41 stations studied. It is common in Eufaula and occasional in Platt Park and the Wichita Refuge, all in the postoak-blackjack forest. It is found in the other associations but is rare.

Outside of Oklahoma this species is reported from the eastern deciduous forest and from the southern pine forest. Apparently it is a forest species. The reported breeding habitat is the tree-holes.

Seasonal incidence.—In the latitude of central Oklahoma, this species appears in about mid-May, with high incidence late in this month or early in June. In the Wichita Mountains it appears about the end of May with high incidence in June.

This species begins to disappear about the end of June. The proportion of males of this species in Oklahoma was 19.6%, which is relatively high.

CULICOIDES VILLOSIPENNIS OKLAHOMENSIS Khalaf

Description.—This is the fourth form belonging to the *villosipennis* group. Only the male of this subspecies has been described previously. It is a dark,

rather large subspecies, very similar to the other members of the *villosipennis* group and superficially like *C. guttipennis*. The female, in size and coloration, corresponds to the male. The last five segments of the antennal flagellum are about one-third longer than the first eight. The second and the third segments of the palpi are subequal; the third segment is well swollen with a small, moderately deep sensory pit; the fourth and fifth segments are subequal. The striped mesonotal pattern is like that of the rest of the members of the group. The knees are dark; the light bands of the legs are like those of the group.

There are two subspherical spermathecae; the base of the duct, unlike that of *C. guttipennis*, is not conically sclerotized, but on the contrary, it is thinly sclerotized and only for a short distance. A rudimentary spermatheca and a ring are present.

The wing maculation is like that of the group. However, the crossvein light spot is large as in *C. arboricola* and *C. guttipennis*, and vein Cu_2 is without light borders.

In the male hypopygium, the harpes are like those of *C. arboricola;* their tip is long and tapering. The aedeagus is also like that of the latter species except that, as in the case of *C. villosipennis*, terminal portion bears projections near the tip. However, there are normally only two projections. In a few specimens from Platt and Wichita Refuge, three projections were present. Hybridization may be actually present among these forms, a phenomenon which the present writer suspects in some other forms also, and probably is responsible for minor differences in the spermathecae and some other structures examined.

Allotype, female, Eufaula (Okla.), May 30, 1947; with about 20 female paratypes, Eufaula (Okla.), 1947; deposited in the University of Oklahoma Museum.

Distribution and population density (fig. 22).—This is a restricted subspecies. It was found in only seven stations, and in low density. In Eufaula the density is a little higher. These stations correspond with the postoak and oak-hickory associations.

Seasonal incidence.—This subspecies was collected mainly in June or very close to this month.

This distribution clearly reflects the heterogeneity of the genus in the state quantitatively and, to a lesser degree, qualitatively with respect to the *Culicoides*. There is also some regularity in this heterogeneity across ecological ecotones.

The first transitional area is that west from the oak-pine forest. The two species *C. p. riggsi* and *C. spinosus* seem to prefer pine-oak forest and are found only in low density in the interior of the state. However, the most conspicuous transitional region is that of the postoak blackjack-tallgrass. This area markedly affects the distribution and the density of the eastern deciduous forest species: *C. biguttatus, C. guttipennis, C. obsoletus, C. v. oklahomensis, C. venustus, C. villosipennis;* and also the grassland species: *C. hieroglyphicus, C. weesei, C. multipunctatus, C. variipennis*. In this transitional area a wider variety of species is expected than in any other area in the state, because such an area will sieve many of the species from passing in either direction. However, it should not be expected that a true grassland

or forest species would have significant incidence in such a transitional region since pure stands optimal for the species are less frequent in such ecotone areas. For another group of species the important transitional region falls beyond the tallgrass prairie, deep in the grassland. This is the case of *C. stellifer, C. travisi, C. ousairani, C. crepuscularis, C. haematopotus,* and *C. arboricola.*

The rest of the Oklahoma species do not seem to have their most favorable habitat in this state, and usually have spotty distribution in the grassland. These are: *C. hinmani, C. jamesi, C. baueri, C. nanus,* and *C. salihi.* However, in this latter case the possible bias in sampling should not be overlooked.

In Oklahoma the clear-winged species and species with dotted mesonotal pattern when found in the eastern deciduous forest are found only as rare species. They seem to be more of grassland species. Those with a light spot on the second radial cell seem on the contrary to be forest species.

The eastern deciduous forest possesses more species than the grassland associations. The short grass association has the least number of species. The postoak-blackjack association harbors the highest number of species, probably because some grassland species that are unable to tolerate the far eastern deciduous conditions are able to live in the less thickly forested postoak-blackjack forest. The presence of more species in forested areas goes hand in hand with the theory of the origin of this genus. The genus seems to have originated in and to have had long association with a more or less forested habitat. The occupancy of grassland is a secondary adaptation.

ECOLOGICAL ASSOCIATIONS AND THE DENSITY OF THE GENUS

The genus was found in every station studied regardless of the type of the association. The density of populations (fig. 1), however, although correlated with the ecological associations, was also edaphic, a phenomenon the location of the light trap takes part in producing.

The genus was common in the oak-pine and oak-hickory forests; in Jay the density is lower than expected. The genus was not abundant in the postoak-blackjack forest; the high density in Seminole, Eufaula, and the Wichita Refuge is probably caused by grassland elements. The possibility of low efficiency of the trap to attract insects in the forest should not be neglected. In the tallgrass prairie the genus, with very few exceptions, was abundant; Kingfisher, Norman, Alva, and Overholser are expected to have higher density than the observed figures show, and their low density might be partly due to the associated forest. In the mixed and sand-sage grassland the density of the populations was also high; Altus and Mangum are expected to have higher densities. The genus was not abundant in the shortgrass plains. In brief, the genus was not abundant in the eastern deciduous forest, but it was often so in the grassland with the exception of the shortgrass plains.

The highest density of the genus is usually associated with swampy areas and sea shores, where the insects may cause great human discomfort. In Oklahoma, however, in a place like Taloga, it has been stated that these biting gnats were abundant enough to drive the fishermen away. Damage caused to cattle by infestation with *C. variipennis,* breeding in the North Canadian waters, has been reported (Hill 1947, after Whitehead 1935).

DISTRIBUTION AND DENSITY OF THE SPECIES IN THE ECOLOGICAL ASSOCIATIONS IN OKLAHOMA

COMMON	OCCASIONAL	RARE
	The Oak-Pine Forest	
crepuscularis	bigguttatus	arboricola
	haematopotus	baueri
	spinosus	guttipennis
	p. riggsi	hieroglyphicus
	venustus	multipunctatus
		obsoletus
		ousairani
		travisi
		stellifer
		variipennis
	The Oak-Hickory Forest	
crepuscularis	biguttatus	arboricola
	haematopotus	baueri
	travisi	guttipennis
	stellifer	hieroglyphicus
	venustus	multipunctatus
		nanus
		obsoletus
		v. oklahomensis
		p. riggsi
		variipennis
		villosipennis
	The Postoak-Blackjack Forest	
	arboricola	baueri
	biguttatus	guttipennis
	crepuscularis	hieroglyphicus
	haematopotus	multipunctatus
	stellifer	nanus
	variipennis	obsoletus
		v. oklahomensis
		ousairani
		p. riggsi
		travisi
		spinosus
		venustus
		villosipennis
		weesei
	The Tallgrass Prarie	
variipennis	crepuscularis	arboricola
hieroglyphicus	haematopotus	hinmani
multipunctatus		jamesi
weesei		ousairani
		travisi
		stellifer
	The Mixedgrass Plains	
hieroglyphicus	crepuscularis	arboricola
variipennis	haematopotus	hinmani
	multipunctatus	salihi
	weesei	stellifer

The Sand-Sage Grassland

hieroglyphicus	crepuscularis	arboricola
	haematopotus	hinmani
	variipennis	jamesi ?
	weesei	multipunctatus
		salihi
		spinosus
		stellifer

The Shortgrass Plains

hieroglyphicus		arboricola
variipennis		baueri
		crepuscularis
		haematopotus
		jamesi
		weesei

SEASONAL INCIDENCE OF THE GENUS IN OKLAHOMA

Time of Appearance and Disappearance.—The time of appearance of the genus and of the individual species, in general, was related to the date of the freedom from frost. The end of the seasonal activity did not seem to depend directly on the date of the first frost.

The genus was of insignificant incidence before late March. In the south, it appeared in about the beginning of April or shortly before that. In the latitude of central Oklahoma there was usually about ten days delay. In the north it was in the second part of April.

In the eastern part of the state the season was shorter; the genus disappeared about August. In the middle and west, it not infrequently continued through part of October. In the eastern part of the state, of the more persistent species, only *C. crepuscularis* and to a less extent *C. haematopotus* were present in a density above the rarity level. This accounts for the early date of disappearance in that part of the state.

There were some station variations from the expected dates given above for each category. For the genus, as well as the species, proper trap location and favorable climate in the season at a station are reflected in a collection of a higher density than average, which is usually accompanied by extension of the season in both directions and vice versa. In Clinton, Stillwater, Perry, Norman, Mangum, and Hobart the late appearance was accompanied by lower density than expected. On the contrary, in Ft. Reno, Sapulpa, and Taloga many species exhibited higher density and longer season than expected. In this sense, population density becomes important when the seasonal incidence is under consideration.

The other ways in which environmental conditions affect the dates under consideration are of a more temporary nature, when favorable or unfavorable weather prevails at the time of appearance or disappearance. Alva seemed to show such an effect. The appearance was early in spite of a higher expected density, probably because of favorable weather at that time. Probably the same was true in Goodwell. In Weleetka the conditions early in the season seem to have been unfavorable. A slight shift in the direction of the wind in relation to the trap at some date may be of great importance in reducing the collection even when the population is high.

The effect of the climate on the genus is also obvious when the incidence is considered outside of Oklahoma. In Mexico, this genus has been reported from as early as February and as late as November. In the United States of America, the genus is of high incidence as early as March along the southern portion of the Atlantic seaboard. In the salt marshes of Florida, Shields and Hull (1943), working with adult recovery cages, reported high incidence as early as December. In Haiti, apparently, the genus may be active the year around. Biting was reported in December. On the contrary, in northern Colorado the genus appears in about mid-May, and persists to about mid-September; and in Alaska the appearance is delayed to the beginning of June. In England, the study made on the genus and the attractivity of the females to dark surfaces showed high incidence from May through July.

Although the incidence of the species that were represented in the total collection with low figures was sometimes wide, such species usually showed affinity to certain parts of the season. *C. baueri* and *C. jamesi* were represented with very few specimens. Each has been collected in two months, and should be expected in others, especially when the wide distribution outside of Oklahoma is considered. The incidence of *C. spinosus* was restricted, but this restriction was highly dependent on the locality. In the southeast, the main incidence was in April. *C. guttipennis, C. venustus, C. obsoletus,* and *C. hinmani* have been collected from different parts of the state in a number of different months. In this state *C. p. riggsi* was an early species and showed affinity to April and May; *C. villosipennis, C. travisi,* and *C. v. oklahomensis* to May and June; *C. nanus* to June; *C. salihi* to June and July.

Probably such seasonal incidence restrictions of these species is inapplicable outside of Oklahoma. The species may have a wide seasonal incidence somewhere outside of this state, and Oklahoma furnishes the proper niches only poorly and but for a very limited time. This restricted time, therefore, represents the time of the year when the pressure of the unfavorable conditions is reduced. However, even within this state, the apparently limited seasonal incidence could be doubted. A few specimens often were present beyond the apparent seasonal limits. It could be that only a smaller section of a wider incidence is taken by this sole method of sampling.

Among the more familiar species (those more dense and widely spread) in the state, the early appearing species in their time of appearance follow more or less the following sequence:

IN THE SOUTH

crepuscularis multipunctatus biguttatus	haematopotus stellifer	hieroglyphicus	variipennis

IN THE LATITUDE OF CENTRAL OKLAHOMA

variipennis hieroglyphicus	crepuscularis haematopotus	biguttatus stellifer	weesei multipunctatus

IN THE NORTH

hieroglyphicus variipennis crepuscularis	haematopotus	stellifer	multipunctatus weesei

In northern Colorado, the figure given by James (1943) for the seasonal incidence indicates that *C. hieroglyphicus* and *C. crepuscularis* are early appearing; while *C. stellifer* and *C. haematopotus* are late appearing species.

The relatively late species in their disappearance follow the following sequence:

weesei	haematopotus	variipennis
multipunctatus	crepuscularis	hieroglyphicus

The last two are usually the most persistent species at the end of the season.

In northern Colorado *C. haematopotus* is like *C. crepuscularis* in its persistence at the end of the season. Relative difference among the British species in relation to each other regarding the seasonal incidence also was observed by Hill (1947).

From this summary it becomes clear that *C. hieroglyphicus, C. variipennis, C. crepuscularis,* and *C. haematopotus* are the species of "long-life" through the season in Oklahoma.

In drawing these conclusions, not only the date of appearance and disappearance in the stations was analyzed, but also the general level of incidence in each station as well as the density at the time of appearance and disappearance. Density of a species above the normal level in a station may indicate unusually favorable conditions that result in spreading the incidence of the species to both extremes of the season. The reverse conclusion is also sometimes true; species appearing earlier or disappearing later than the expected dates might be of high incidence through the season. Unusual delay in the time of appearance of an early species might be the result of unfavorable conditions for that species in particular. A sudden late appearance of such species at a high level may be also the result of such a factor.

HIGH INCIDENCE

The time of high incidence for the genus was as follows:

In the south, in April.

In the north; in the east and in the Wichita Mountains in June, with longitudinal delay due west.

In the latitude of central Oklahoma; in the east in late April and May, in the west in about June.

There were some variations from the outline given above. The presence of additional peaks was not infrequent. In Nowata the high incidence continued to as late as October; in Waurika, there was an additional peak in September; in Ft. Reno, another peak in August; in Norman, a late peak in October; in Poteau the high incidence continued to as late as the end of June.

C. haematopotus, C. hieroglyphicus, C. multipunctatus were very similar regarding the time of the high incidence. In the south it was as early as April, in the latitude of central Oklahoma it was as early as May, in the north it was in June. With partial exception of the south, a peak may be encountered as late as October. *C. crepuscularis* was much like the previous group except in the latitude of central Oklahoma the peak was also in June and there was no peak beyond August. For *C. variipennis* and *C. weesei* the peak may be encountered between May and October. For the last mentioned

species it was mainly in June or July. The peak for *C. stellifer* was somewhere in these two months.

The above summary involves two opposing phenomena: (1) The effect of more generalized factors that operate on areas of a large extent (2) The importance of the edaphic factors which are responsible for the variations within the large area. In this last category the factors with which the incidence is linked may be unusually favorable or unfavorable. The species may take advantage of such favorable conditions as are displaced in the season, and on the other hand may show unexpected drops in incidence because of unfavorable conditions.

The Proportion of Males

On the basis of 87,174 specimens, the proportion of males for the genus in this light trap survey was $13.1 \pm .1\%$.

The observed proportion of males of the genus varied with the stations between 3.4% to 37%. These variations in many cases are statistically insignificant. This is sometimes true even when the difference was large on account of the high value of the standard errors concerned. However, Weleetka, Poteau, Fairview, Taloga, and Elk City showed significantly low proportions of males, while on the contrary the genus in Platt, Clinton, Norman, Pond Creek, Waurika, Anadarko, Lake Overholser, Doby Springs, and Goodwell showed significantly high proportions of males.

If the proportions of males of the different species in the total collection are arranged in succession of their values, with consideration to their standard errors, it could be shown that *C. haematopotus, C. arboricola, C. ousairani, C. multipunctatus, C. crepuscularis,* and *C. weesei* possess high male proportions. The proportion of males of *C. variipennis* does not seem to differ significantly from that of the genus as a whole. *C. hieroglyphicus* and *C. stellifer* possess low proportions of males. *C. nanus, C. venustus,* and *C. biguttatus* had still lower proportions.

With respect to the proportion of males of a species in the different stations or of the different species in the same station, there often seems to be great variation. However, in many instances the standard errors were so high as to conceal any difference that might otherwise be present if larger samples were available.

Finally, the lower proportion of males regardless of the species is striking. Hill (1947), working with *C. impunctatus,* found that the proportion of males and females which hatched from pupae were approximately the same. This might suggest the hypothesis of low attractivity of males to the traps in spite of the fact that the percentage of males of some species, in some stations, was beyond 50%. However, the light traps in the stations were placed in the vicinity of about the same general type of habitat; near the probable breeding sites of mosquitoes and such biting gnats. If the male, therefore, has different habits from the female, especially in relation to the breeding sites, this will show up in the collection as a low percentage. Net sampling revealed only 3% males (Hill 1947). The reason for this low male proportion was attributed to a possible greater preference of females to sheltering in herbage. The probability that males may have a shorter life span should not be overlooked.

SUMMARY

In this light-trap survey of the adult *Culicoides* in Oklahoma 87,174 specimens were examined from 41 stations distributed in the state. Twenty-three species and subspecies are present, including *C. piliferus riggsi* new subspecies. The females of *C. v. oklahomensis* Khalaf were collected and described.

A check list of the *Culicoides* is given in which the species are arranged according to their density and extent of distribution in the state. This list includes also the proportion of males.

In addition to the two types of familiar keys (based on external characters and male genitalia) the writer attempted a third type of key for the species of Oklahoma which is designed to be used for the cleared female.

Probable bias in the function of the light trap is referred to in the discussion. Study for more than one season carried out in the Wichita Refuge and at Lake Overholser showed a high degree of correlation in the incidence in the two seasons.

Under the heading of each species the following items are discussed: (1) Diagnosis (or description) and morphological variations. The superficial similarities and interrelations of Oklahoma species are discussed to aid their proper identification in this local fauna. (2) Proportion of males compared to that of other species and in the different stations. (3) Distribution and population density in relation to the biotic communities. Locality records outside of the state (when available) are also interpreted ecologically. The advantage of such ecological treatment over the geographical one should not be overlooked, although the ecological distribution may stand short because of latitudinal barrier. (4) Seasonal incidence, in relation to the latitude and longitude (the frost period) and in the light of the expected densities.

For each biotic association, a list of species with their expected densities is given. Most of the physiographical barriers are of less importance than the ecological ones. Ecotones are evident.

The observed population density of the genus has been discussed in the various associations. A general account of the seasonal incidence of the genus and the species is given. The relative seasonal incidence for each species is also discussed. A separate account for variations in the proportion of males of the genus is given. This account also includes significant variations in this proportion for the different species in the total collection, of the individual species in the various stations, and of the different species in the same station. Probable reasons for such variations are advanced.

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Ecology of the Central Mudminnow, Umbra limi (Kirtland)*

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Ecological studies of the freshwater fishes are far from complete. Studies relevant to the life history of the Umbridae are particularly lacking. This fact, plus the presence of a large local population of *Umbra limi*, prompted this investigation.

Our study of the ecology of the central mudminnow was concentrated on a population from Judy Creek, a small stream in St. Joseph County, Indiana, which empties into the St. Joseph River north of South Bend, Indiana. The stream is approximately 10 miles in length and 20 feet at its widest part. It is a favorite trout stream of the locality and is stocked periodically. In the area of the stream where the mudminnows are plentiful, approximately one mile northeast of the University of Notre Dame campus, the bottom consists of sandy loam with moderate amount of aquatic vegetation along banks. Throughout the greater part of the year the stream has a maximum depth of from 2 to 3 feet. From the mouth of the stream to a point approximately 4 miles upstream, it is rock-strewn with very little aquatic vegetation, and the mudminnow is noticeably absent. Similarly, the mudminnow is scarce at the headwaters of the stream where the depth of the water is less than one foot.

Habitat

The usual habitat of the adult mudminnow in Judy Creek is along the margins of the stream where vegetation is dense, thus affording them good protection from predators. Occasionally a few specimens were collected in midstream where aquatic vegetation was dense. *Nasturtium officionale* is the predominant aquatic plant along the banks and is the favorite haunt of this fish. Following heavy rains, the fish were absent from their usual habitat but could be found in the flooded areas along the banks of the stream. In this manner the mudminnow seems to avoid strong water currents. Further evidence is indicated by the absence of this species at all times in those parts of the stream where the current is swift. In the early spring the rise in temperature of the water and the rise in water level of the stream with subsequent overflow forming suitable breeding niches, perhaps act as stimuli for spawning. These areas of overflow provide excellent breeding ground for the adults and protected habitats for the young.

Abbott (1870) reports that fish, hibernating in the mud, "burrow tail

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foremost to a depth of from four to nine inches . . . ," in midwinter. Although Abbott's account of hibernation is referred to in most summary accounts of this species, no additional evidence to substantiate this observation appears in the literature. The ability of *Umbra* to survive low oxygen tension has been reported by Geyer and Mann (1939) but hibernation for several months in four to nine inches of mud is contrary to our results.

On November 30, 1953, following a week of freezing weather, mudminnows were collected from the vegetation along the edge of the stream. On December 18th the creek was covered by one-half inch of ice. The layer of ice overlying the vegetation was broken and mudminnows were obtained with each haul of the seine. Upon capture these fish were active and did not appear to be in a state of hibernation. Fish kept in aquaria in which the bottom consisted of mud were never observed to dive into the mud when startled as has been frequently reported, although movement with the tail foremost was observed. Adult fish would seek vegetation under which they would conceal themselves and in so doing make the immediate habitat turbid. The stomachs of fish, removed from the ice-covered stream, contained food. The vegetation from which they were seined supported an abundant supply of insect larvae and crustaceans. On January 14, 1954, twenty-one fish were collected from under two inches of ice. An attempt was made to seine among the vegetation without disturbing the underlying mud. The number of fish collected in this fashion equalled the number collected when the mud was stirred vigorously. On February 2, 1954, there was no ice on the stream, air temperature reached 3.3 degrees C and fish were plentiful along the banks of the stream. All of the mudminnows collected during the winter were active and most of the stomachs contained food. The habitat was the same as during the summer months.

BREEDING HABITS

The breeding behavior of *Umbra pygmaea* apparently was observed in aquaria by Carbonnier (1874), and the results of the observations published as observations on *Fundula cyprinodonta,* Cuvier. Ryder (1886) gives a short description of the early developmental stages of *Umbra limi* before and shortly after hatching. The ova measured 1.6 mm in diameter and are laid singly upon aquatic plants. The young hatch on the sixth day at which time they have reached 5 mm in length. Ryder also pointed out the peculiar development of the tail, further described and figured by Breder (1933) for *Umbra pygmaea.*

The spawning of mudminnows in early spring has been noted by Abbott (1870), Forbes and Richardson (1907), Wright and Allen (1913), Evermann and Clark (1920). In Judy Creek on February 16, following a heavy rain, (2.5 inches in 24 hours) no fish could be found along the normal margin of the stream. The high water level remained until after the spawning period. On March 10, mudminnows were still abundant in the areas of overflow where they were seined at times in water two to four inches in depth. Both males and females were taken together in ditches and pools along the edge of the stream and in some instances 15 to 20 feet from the main stream. On April 9, 1954, all females collected were gravid. By April 29, all females collected, with a few exceptions, were completely spent; one female (57 mm), and

Fig. 1.—Typical breeding pool (right foreground) of *Umbra limi* in Judy Creek.

another (60 mm), retained a few eggs, each 1.2 mm in diameter. Flood conditions were prevalent at breeding time; the majority of the spent females were recovered from overflow areas. On April 30, prolarvae measuring 8 mm were collected in a flooded area (fig. 1).

Evermann and Clark (1920) observing specimens from Lake Maxinkuckee, Indiana, found ripe females with eggs 1/20 inch in diameter and varying in number from 425-450 per individual. Egg counts were made on thirty-six individuals collected from Judy Creek in November and December, 1953, and in March of 1954 (table 1). Counts were made by removing both ovaries and counting all eggs. In individual ovaries all eggs were the same size before the breeding season and evidently ripen at the same time, which would seem to indicate a short spawning period.

MIGRATION

The occurrence of spawning migrations were reported by Abbott (1870) in which he observed nearly ripe females migrating upstream unaccompanied by males from which they had been segregated prior to the spawning migration. No mass migration of females nor segregation of sex prior to spawning was observed in Judy Creek. Little movement up and down stream was noted except emigration from areas in which thick deposits of silt covered previous areas of aquatic vegetation.

Migration consisted of lateral movements at any time of the year in response to flood conditions and during the breeding season in response to

flood conditions and availability of proper breeding areas. The young moved from the breeding areas to the main stream at approximately 30 mm in length or perhaps earlier upon drying up of the flooded areas.

SEXUAL DIMORPHISM

In the collections of November 1953 a number of adults were observed with a bluish-green iridescence on the anal fin. All fish colored in this manner were found to be males. The coloration of the anal fin is present throughout the year but with greatest intensity just previous to and during the breeding season. Also, the larger adult males possess coloration on the pelvic fin at the height of the breeding season. Westmann (1941) observed the coloration of the anal fin of males and noted also that the anal fin is noticeably longer in the males. In the population from Judy Creek most of the males could be readily distinguished from females because the depressed anal fin almost reaches the base of the most ventral hypochordal ray of the caudal fin and extends well beyond the depressed dorsal. Of four male specimens of *Umbra pygmaea* examined, the depressed anal extended somewhat further posteriorly than did typical male specimens of *Umbra limi*.

PARASITES

Although no extensive observation was made of parasites on fish from this population, *Clinostomum complanatum*, the yellow grub, Hunter (1954, personal communication), was a common parasitic trematode of the mudminnow in Judy Creek. Of 167 fish examined from November, 1953, to March, 1954, 10 percent contained heavy infections of the metacercariae of this trematode. The usual sites of infections were 1) the gill and throat region, 2) the region behind, and in, the orbit of the eye, and 3) the skin and fins to a lesser extent. The smaller fish appeared to be more heavily infected. One fish (47 mm) contained 129 metacercariae. The swimming movements of this fish were hindered and secondary infections of bacteria and/or fungi undoubtedly produce additional effects.

A species of *Gyrodactylus* was common on the skin and gills. This parasite was common on 10 to 15 mm larvae collected in May. When young

TABLE 1.—Egg counts

Range in mm	No. individuals	No. eggs maximum	No. eggs minimum	Mean
		Judy Creek		
52-57	6	220	571	339
60-69	13	202	758	449
71-79	7	304	1175	737
81-94	10	379	1489	957
		Volinia, Michigan		
77-92	4	487	903	773

TABLE 2.—Seasonal variation in the food habits of *Umbra limi* from Judy Creek. Number of organisms and percent frequency (parenthesis)

	1953		1954									
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Total
No. of fish examined	53	25	21	35	30	47	67	73	77	19	51	498
Size range (mm)	49-94	48-86	40-66	41-93	32-94	42-87	10-85	16-87	26-117	52-92	30-94	
No. of empty stomachs	8	1	0	2	4	22	3	16	16	4	7	83
Food items												
Ostracoda	79 (50.6)	377 (69.7)	69 (57.6)	180 (72.0)	99 (60.8)	94 (68.0)	87 (64.0)	103 (43.2)	18 (12.8)	—	21 (17.6)	
Copepoda	76 (44.0)	68 (53.3)	13 (43.2)	68 (45.0)	31 (45.6)	13 (20.0)	175 (44.8)	50 (27.0)	11 (8.0)	—	23 (24.2)	
Amphipoda	3 (6.6)	5 (16.4)	—	1 (3.0)	—	—	—	—	7 (3.2)	—	1 (2.2)	
Isopoda	—	—	16 (43.2)	2 (6.0)	5 (19.0)	1 (4.2)	—	4 (5.4)	—	—	—	
Insects												
Chironomid larvae and pupae	78 (26.4)	24 (45.1)	19 (52.8)	19 (27.0)	130 (41.8)	26 (36.0)	99 (65.6)	86 (68.4)	19 (22.4)	—	42 (57.2)	
Other immature insects	17 (26.4)	14 (49.2)	48 (67.2)	19 (54.0)	17 (38.0)	10 (32.0)	53 (38.4)	37 (36.0)	15 (19.2)	9 (53.6)	11 (24.2)	
Adult insects	6 (11.0)	3 (4.1)	2 (9.6)	3 (6.0)	1 (3.8)	2 (8.0)	6 (8.0)	2 (3.6)	4 (4.8)	—	—	
Arachnida	3 (4.4)	—	—	1 (3.0)	1 (3.8)	—	1 (1.6)	6 (7.2)	4 (6.4)	—	6 (8.8)	
Mollusca	41 (37.4)	7 (24.6)	—	3 (9.0)	4 (7.6)	6 (8.0)	8 (12.8)	46 (27.0)	12 (12.8)	7 (26.8)	14 (22.0)	

free of infection were placed in close proximity to infected fish, the parasite would pass readily from one fish to another. The gyrodactylid present on the skin and gills of *Umbra limi* from Judy Creek differs considerably from *G. cylindriformis,* Mueller, originally described from *Umbra limi,* and is described as a new species (*G. limi,* Wood and Mizelle, 1957). A common parasite of the urinary bladder was a trematode, *Phyllodistomum brevicecum.* Usually one but occasionally two parasites were found in the urinary bladder.

FOOD HABITS

The numerous accounts of the diet of the central mudminnow in the literature are based on a small number of specimens taken at different seasons of the year and do not consider the seasonal variations within a single population nor the variation in the diet within different age classes. There is general agreement that *Umbra limi* is a carnivorous species, however, Hubbs and Lagler (1949) state "This fish is apparently omnivorous, although principally carnivorous, feeding upon certain insect larvae and minute crustaceans in addition to a certain amount of plant material."

Specimens were collected monthly from Judy Creek during the period November 1953 to September 1954 in order to determine the extent of seasonal variation in the diet of the mudminnow population. The stomach contents of 498 mudminnows were examined in this portion of the study (table 2). Fish (639) used to determine variation in diet according to size were separated into 10 mm size groups (table 3). Also, 63 mudminnows from various localities in southern Michigan were examined for comparison. A total of 702 stomachs of fish ranging in size from 10 mm to 135 mm, was examined.

The specimens from Judy Creek were etherized immediately, placed in 10 percent formalin for 2 hours, then preserved in 70 percent alcohol. Fish placed directly in 10 percent formalin often regurgitate part or all of the stomach contents and prolonged preservation in formalin resulted in deterioration of the otoliths which were used in age determination.

The total length of each fish was recorded in millimeters. Since *Umbra limi* has a rounded caudal fin, total length was measured from the distal end of the median caudal fin ray to the tip of the protruding lower jaw.

The stomach contents were identified and recorded according to number and percent frequency; that is, number of fish stomachs containing each food item divided by the total number of stomachs containing food (tables 2 and 3).

The stomachs of 121 mudminnows were empty; 44.6 percent males, 52.1 percent females, and 3.3 percent unsexed. Many of the empty stomachs (about 20%) were from fish collected during the breeding season. Very few stomachs were empty in the collections from the winter months (table 2).

Small Crustacea (Ostracoda, Cladocera, Copepoda) were important food items particularly in young fish (table 3). The decrease in numbers of small crustaceans taken during the warmer months was correlated with the greater availability of active, larger food organisms and the growth of the mudminnow (table 2). Amphipoda (*Gammarus*) were abundant from Judy Creek, particularly during the winter and they were eaten by the mudminnow in aquaria. However, under natural conditions amphipods were found in the stomachs in

TABLE 3.—Variations in food habits in relation to size of *Umbra limi* from Judy Creek. Number of organisms and percent frequency (parenthesis)

Range (mm)	10-19	20-29	30-39	40-49	50-59
No. of fish examined	37	21	33	49	163
Food Item					
Ostracoda	75 (76)	62 (62)	47 (32)	111 (63)	506 (52)
Cladocera	26 (17)	5 (10)	32 (23)	6 (58)	—
Copepoda	163 (78)	71 (76)	34 (39)	98 (50)	201 (40)
Amphipoda	—	—	1 (+)	1 (5)	5 (+)
Isopoda	—	—	—	1 (+)	15 (9)
Decapoda	—	—	—	—	—
Insects					
Ephemerida	—	—	3 (10)	10 (20)	31 (10)
Chironomidae larvae-pupae	75 (78)	40 (67)	34 (58)	42 (53)	208 (43)
Trichoptera	—	—	—	8 (13)	27 (10)
Mollusca					
Physa sp.	4 (8)	3 (5)	1 (6)	10 (15)	17 (8)
Stagnicola sp.	—	—	—	—	5 (+)
Others	3 (5)	1 (5)	2 (+)	—	6 (+)

smaller numbers than the relative abundance would indicate. Two Isopoda (*Asellus communis* and *Tracheoniscus rathkii*) and crayfishes were eaten occasionally.

Insects formed an important part of the diet of the mudminnow. Chironomid (Diptera) larvae and pupae were one of the main constituents of the diet, forming the principal item in smaller fish and gradually decreasing in number with the increase in size of the fish (table 3). Mosquito (Culicidae) larvae and pupae were common in the breeding areas of the mudminnow during April and May, but only a few stomachs contained these immature stages. This is contrary to the suggestion of Petit (1902) that fewer mosquito larvae are found in pools inhabited by the mudminnow. Species of other families of Diptera were eaten occasionally, namely, Dixidae, Dolichopodidae and Tipulidae.

Mayflies (Ephemerida) were consumed by fish over 30 mm and occurred

TABLE 3.—(*continued*)

	60-69	70-79	80-89	90-99	100-135	Totals
No. of fish examined	156	103	53	13	11	639
Food Item						
Ostracoda	188 (22)	19 (16)	16 (17)	4 (+)	—	1028 (38)
Cladocera	307 (+)	—	—	—	—	376 (8)
Copepoda	91 (26)	18 (8)	7 (10)	5 (+)	—	688 (34)
Amphipoda	2 (+)	4 (6)	11 (7)	1 (+)	—	25 (3)
Isopoda	8 (4)	2 (4)	—	1 (+)	—	27 (4)
Decapoda	4 (+)	2 (+)	1 (+)	—	4 (+)	11 (2)
Insects						
Ephemerida	27 (15)	9 (11)	3 (10)	4 (25)	1 (+)	88 (10)
Chironomidae larvae-pupae	182 (45)	41 (38)	22 (24)	4 (25)	5 (42)	653 (46)
Trichoptera	85 (14)	11 (8)	14 (15)	—	—	145 (10)
Mollusca						
Physa sp.	30 (13)	16 (16)	6 (10)	3 (25)	5 (42)	95 (11)
Stagnicola sp.	15 (+)	10 (7)	1 (+)	—	—	31 (3)
Others	14 (7)	18 (10)	1 (+)	1 (13)	—	46 (5)

in 10 percent of all stomachs examined. Caddis flies (Trichoptera) were taken by about 10 percent of the mudminnows over 40 mm long (table 3). True bugs (Hemiptera) occurred sporadically in the stomachs and were represented by Belostomatidae, Notonectidae, Corixidae and Gerridae. Beetles (Coleoptera) were found in only 23 stomachs. Representative families were Dytiscidae, Gyrinidae, Haliplidae, Hydrophilidae, and Staphylinidae. The naiads of dragon flies and damsel flies (Odonata) were very common in Judy Creek, but only 13 stomachs contained specimens, one in each stomach.

Molluscans were found most frequently in the stomachs from the spring and summer collections. Young mudminnows (19 mm) ate newly hatched snails. *Physa* was the predominant molluscan in the diet (table 3). *Stagnicola* and Sphaeriidae were eaten in considerable numbers.

Other invertebrates occurred in a few stomachs, namely, water mites (Hydracarina), spiders, millipeds, spring tails (Collembola), ants, leeches, and

earthworms. Earthworms appeared in only six stomachs, but living earthworms are eaten readily by adult mudminnows kept in an aquarium.

One *Rhinichthys atratulus* (30 mm) was found in the stomach of an 80 mm mudminnow and two unidentified fish were present in the stomach of an 85 mm mudminnow.

Scales from the mudminnow were not uncommon in the stomachs of the mudminnow. These scales were not the result of contamination during dissection, but whether or not they were due to random chance while the mudminnow fed along the bottom could not be determined.

Sixty-three mudminnows ranging from 32-110 mm were examined from various streams in Michigan. Comparison of the data from this sample with the data of the adult population from Judy Creek during the same months shows a great similarity in the percent frequency of the various food items.

The stomach contents indicated that the mudminnow is a bottom feeder and not a surface feeder to any extent. Also this population was practically 100 percent carnivorous. Plant material appeared to be accidental in the diet of the mudminnow.

Competitors for Food in Judy Creek

The following species are associated with the mudminnow in Judy Creek and may be considered directly or indirectly in competition for available food: *Rhinichthys atratulus meleagris, Cottus bairdi, Catostomus commersoni, Lepomis cyanellus, Notropis cornutus, Campostoma anomalum pullum, Esox americanus vermiculatus,* and *Salmo gairdneri.*

Stomachs of the sculpin, *Cottus bairdi,* frequently contained mudminnows. Considering the abundance in Judy Creek, *C. bairdi* was the chief predator. On April 9, the stomach of one male cottid (111 mm) contained a female mudminnow (72 mm) with eggs; another sculpin (102 mm) had consumed a female 65 mm long. Some loss of potential young occurs due to predation by sculpins. However, the spawning area of the mudminnow, the flooded areas, is apart from the habitats of the sculpin and trout which favor sandy, rocky areas in the main stream. Thus, the shift of the mudminnow population out of the main stream is an important factor in the survival of the eggs and of the young of *Umbra limi.*

Summary

The mudminnow inhabits the margins of the stream where the vegetation is dense. There is no evidence of hibernation. In winter the fish remain active among the vegetation under the ice and a higher percent of the stomachs contain food than any other season. Migration of the population is limited to lateral movements from the main stream into flooded areas following heavy rains. The breeding season is correlated with flooding of adjacent areas. The rise in the temperature of the water and the forming of suitable breeding habitats act as stimuli for spawning. Spawning occurs in April in the shallow pools of the flooded areas, which give excellent protection to the adults and the developing young. The number of eggs per female range from 220 to 1489.

Sexual dimorphism occurs in the central mudminnow in the form of a

longer and a bluish-green coloration of the anal fin in the males. Also, the pelvic fin is colored in the larger males during the breeding season.

Common parasites include *Clinostomum complanatum, Gyrodactylus limi,* and *Phyllodistomum brevicecum.*

In Judy Creek the central mudminnow is a carnivorous, bottom feeder. Chironomids, copepods, ostracods, and cladocerans are the principal food items of the young of the year. Small crustaceans are less important to the adults. In addition to the chironomids, mayflies, caddis flies, and mollusks are the chief foods. A few fish are eaten by the mudminnow. Plant material appeared to be accidental in the diet.

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The Cave, Spring, and Swamp Fishes of the Family Amblyopsidae of Central and Eastern United States

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In 1842, DeKay published the first fragmentary description of the Mammoth Cave blind fish, *Amblyopsis spelaea.* Subsequently, Putnam (1872), Packard (1886), Cox (1905), and Eigenmann (1909), have reviewed the species and characteristics of the family Amblyopsidae. The brief monograph by Cox defined the genera, described the species, with a key for separating them, and postulated a phylogeny. Starks (1904) described and compared the skeletons of the pike, *Esox,* the mudminnow, *Umbra,* a topminnow, *Fundulus,* and *Amblyopsis.* Eigenmann began to study amblyopsids in 1886 and published a number of papers dealing particularly with the evolutionary significance of degeneration of the eye. This work was completed in 1909 with publication of a monographic treatise on all cave vertebrates of North America. Since then no one has studied the entire family.

We have not attempted to compare or correlate our information with that concerning the blind cave tetra (*Anopichthys*), the blind catfishes, or the blind brotulids. We have limited our study and remarks to the North American cave, spring, and swamp fishes belonging to the family Amblyopsidae.

Materials and Methods

All of the rays of the dorsal, anal and pectoral fins having separate bases were counted including the two or three rudimentary rays anterior to the principal rays. Only the branched caudal rays were counted. Measurements were taken with vernier calipers following the standard methods described by Hubbs and Lagler (1947). The measurement, vent to origin of anal fin, is given as a fraction of the standard length. The vertebrae were counted on both stained and X-rayed specimens.

Fishes were X-rayed in the following numbers: *Chologaster cornutus*—4 (side only), *C. agassizi*—6 (top and side), *Typhlichthys subterraneus*—1 (top and side), *Amblyopsis spelaea*—6 (top and side). In addition the following were stained with alizarin: *C. agassizi*—2, *T. subterraneus*—2, *A. spelaea*—3, *A. rosae*—1. One *C. cornutus* was dissected but not stained. For staining specimens preserved in alcohol were rinsed in distilled water and placed in a 0.2% solution of potassium hydroxide for 15 or 20 minutes. To this solution was added enough of the clear liquid from a saturated solution of alizarin in 95% alcohol to make a rich purple color. As staining proceeded the fin rays and branchiostegal rays were counted and one side of the specimen carefully skinned. Later when the staining was completed the softened tissue was stripped away and the specimen gradually dissected. Once stained the

specimen was replaced in 50 to 70% alcohol until dissection was completed. The muscle tissues were softened but not allowed to become swollen or gelatinous. By this method we were able to determine origin of some ligaments and attachment of various bones that would not have been possible had the specimen been stained and cleared by the usual techniques.

This study was based on specimens from the Charleston Museum (CM); the University of Illinois (IU); the University of Kansas (KU); the University of Missouri (MU); the National Park Service (NPS); the Natural History Museum, Stanford University (SU); the University of Michigan Museum of Zoology (UMMZ); and the United States National Museum (USNM) as well as material from the collections of our own institution (Chicago Natural History Museum—CNHM).

Acknowledgments.—For the use of these fishes we are indebted to the authorities of the above agencies and institutions.

While in the field, we received considerable help from many people. We are especially grateful to our former colleague, Mr. Robert Kanazawa, now of the United States National Museum; to Dr. H. T. Kirby-Smith of Sewanee, Tennessee; Mr. George F. Jackson, Evansville, Indiana; Mr. Charles Rothrock, Wyandotte, Indiana; Mr. Henry Lix, National Park Service; and Dr. E. R. Pohl, Mammoth Onyx Cave, Kentucky.

Dr. J Harlen Bretz, Homewood, Illinois, not only put the manuscript of his exhaustive catalogue of the caves of Missouri at our disposal, but he also discussed with us the processes of cave formation and the possibilities of cave fish dispersal.

Other colleagues have been helpful in many ways. Dr. Rainer Zangerl, Chicago Natural History Museum, made X rays and suggested methods of staining and photography. Dr. E. M. Nelson, Stritch School of Medicine, Loyola University, Chicago, discussed problems of amblyopsid morphology with us. Drs. R. M. Bailey, University of Michigan, G. S. Myers, Stanford University, E. C. Raney, Cornell University, and L. P. Schultz, United States National Museum, contributed locality records and ideas on the relations of amblyopsids to other families. Messrs. E. Milby Burton, Charleston Museum, and T. C. Barr, Jr., Vanderbilt University, supplied us with locality records that we otherwise would not have had.

KEY TO THE SPECIES OF AMBLYOPSIDAE

A. Postcleithrum present,* none or one row of sensory papillae on each half of caudal fin. (see fig. 4.)

B. Eyes present .... *Chologaster*

C. Branched caudal rays 9 to 11; dark lengthwise streak on lower half of sides. Range: Atlantic Coastal Plains from Virginia to central Georgia .... *C. cornutus*

CC. Branched caudal rays 12 to 16 (rarely 11); pale translucent pink (pale brown in preservative), no dark streak on sides. Range: Central Tennessee, southern and western Kentucky, southwestern Illinois .... *C. agassizi*

BB. Eyes absent .... *Typhlichthys*

Normally no pigment on body.† Range: Middle Tennessee and northern Alabama, in and along the eastern side of Dripping Springs Escarpment of Kentucky; Ozark Plateau of Missouri, northern Arkansas and northeastern Oklahoma .... *T. subterraneus*

* Presence or absence of postcleithrum is very easily determined by making a slit in the skin of the axilla, lifting the fin base, and gently dragging a needle across body muscles of the area thus opened.

† Pigment and pattern develops on living individuals kept in light. Occasional individuals with minute pigment specks.

AA. Postcleithrum absent, two or three rows of sensory papillae on each half of caudal fin (see fig. 5) .... *Amblyopsis*

D. Small ventral fins present. Range: Mammoth Cave region of Kentucky and caves of unglaciated portion of southcentral Indiana ....*A. spelaea*

DD. Ventral fins absent. Range: southwestern Missouri (so far only in Jasper, Greene, Newton, Stone and Barry Cos.) ....*A. rosae*

Table 1 presents a list of the statistically significant differences between samples at our disposal. The outstanding feature of this table is the consistent occurrence of interspecies differences as compared to the sporadic occurrence of intra-specific differences.

The counts for all forms are summarized in table 2.

TABLE 1.—Statistically significant intra-generic differences between samples of amblyopsid fishes

	Amblyopsis	*Chologaster*	*Typhlichthys*
Dorsal rays	*spelaea-rosae*	*agassizi-cornutus* *agassizi:* Illinois-Tennessee	
Anal rays	*spelaea-rosae*	*agassizi-cornutus*	
Pectoral rays		All *agassizi:* Illinois-Livingston, Ky. Illinois-Edmonson, Ky. Livingston-Edmonson, Ky. Tennessee-Edmonson, Ky.	Kentucky-Tennessee Kentucky-Alabama
Branched caudal rays	*spelaea-rosae*	*agassizi-cornutus*	Tennessee-Missouri
Pelvic rays	*spelaea-rosae*		
Caudal papillae	*spelaea-rosae*		
Head length		*agassizi-cornutus* *agassizi:* Illinois-Livingston, Ky. Illinois-Tennessee	Kentucky-Tennessee Kentucky-Alabama Kentucky-Missouri
Head width	*spelaea-rosae*	*agassizi-cornutus* *agassizi:* Illinois-Tennessee	Missouri-Alabama
Anal-vent	*spelaea-rosae*	*agassizi-cornutus* *agassizi:* Illinois-Edmonson, Ky. Illinois-Tennessee Edmonson, Ky.-Tennessee	
Depth		*agassizi-cornutus* *agassizi:* Illinois-Tennessee	

CHOLOGASTER Agassiz

Chologaster Agassiz, 1853, p. 135—type *C. cornutus* Agassiz.
Forbesella Jordan and Evermann, 1927, p. 503—type *Chologaster papilliferus* Forbes.
Forbesichthys Jordan, 1929, p. 68—new name for *Forbesella*.

According to Jordan and Evermann (1927), the presence of tactile papillae distinguished *Forbesella* (=*Forbesichthys*) from *Chologaster*. This difference is not borne out by examination of *C. cornutus*.

CHOLOGASTER CORNUTUS Agassiz—Ricefish

Fig. 1

Chologaster cornutus Agassiz, 1853, p. 135—rice fields of South Carolina.
Chologaster avitus Jordan and Jenkins, in Jordan 1888, p. 356, pl. 44, fig. 8—Lake Drummond, Suffolk, Virginia.

Material examined.—Georgia 1 (USNM); North Carolina 3 (USNM); South Carolina 20 (16-CM; 1-CNHM; 3-UMMZ); Virginia 11 (2-UMMZ; 9-USNM).

Diagnosis.—Eye well-developed, clearly visible under skin, with distinct pupil; scleral cartilages absent; postcleithrum present; body pigmented; pelvics absent; each half of caudal usually with a single row of sensory papillae.

Dorsal 9-12 (usually 11); anal 9-10 (usually 9); pectoral 10-11 (usually 10); branched caudals 9-11; vertebrae 27-29 (4 specimens).

Total length 19.5-51.5 mm; standard length 15.0-41.0 mm; head length 0.311-0.388; head width 0.163-0.217; depth 0.156-0.217; anal-vent 0.047-0.485.

Color (in alcohol) brown in upper half of body, pale buff or yellow in lower half,

TABLE 2.—Summary of counts of species of Amblyopsids

	Dorsal rays						Anal rays				
	7	8	9	10	11	12	7	8	9	10	11
Chologaster											
cornutus			1	2	16	2			14	7	
agassizi			6	23	2				8	21	2
Typhlichthys	4	43	31	1			3	37	35	1	
Amblyopsis											
spelaea			2	39	2			1	18	23	1
rosae	12	7						12	6		

	Pectoral rays				Branched caudals							
	9	10	11	12	9	10	11	12	13	14	15	16
C cornutus		18	2		5	7	7					
C. agassizi	14	10	6	1			1	2	2	13	8	3
Typhlichthys	2	23	48	7		3	6	11	10	2	1	
A. spelaea	3	32	7				2	8	6			
A. rosae		14	3	1	3	2	3					

	Pelvics*						
	0	1	2	3	4	5	6
A. spelaea	1	1	2	18	58	7	1

* Both fins listed separately.

the two areas sharply demarcated; a narrow longitudinal dark line lying about one-third the distance from mid-dorsal to mid-lateral line at boundary between dark dorsal and light ventral areas; light ventral area bisected by a dark streak, wider anteriorly, running from base of pectoral to base of caudal. Pectoral and anal with streaks of pigment along rays; dorsal basally dark, with a broad dark transverse streak in the distal half of the fin; caudal dark with colorless margins, broader dorsally and ventrally than distally.

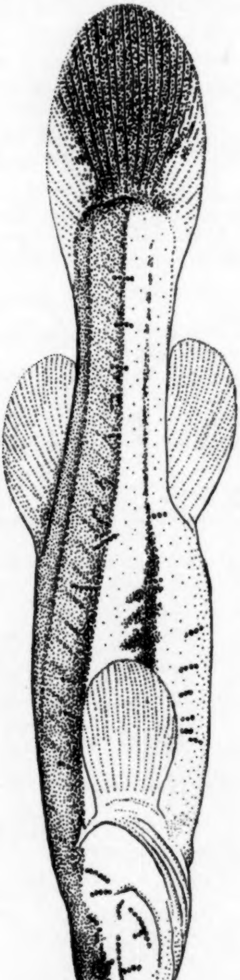

Fig. 1.—*Chologaster cornutus* (x 3).

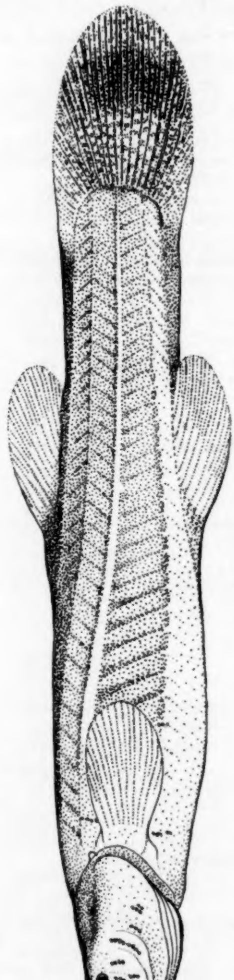

Fig. 2.—*Chologaster agassizi* (x 3).

TABLE 3.—Comparison of various populations of *Chologaster agassizi* and *Chologaster cornutus*

		Dorsal	Anal	Pectoral	Branched caudals	Head length*	Head width*	Anal to vent*	Depth*	Eye*
agassizi Illinois	Range	10-11	9-10	9-10	11-16	238-309	143-181	362-434	143-198	273-407
	Mean	10.2 ± 0.1	9.8 ± 0.1	9.2 ± 0.1	13.9 ± 0.4	273 ± 4	161 ± 7	401 ± 4	164 ± 4	336 ± 9
	No.	11	11	11	11	23	24	24	23	15
Ky.-Livingston	Range	9-10	9-11	9-11	14-15	218-269	146-155	343-457	153-167	245-374
	Mean	9.8 ± 0.2	10.0 ± 0.3	9.8 ± 0.2	14.2 ± 0.2	242 ± 10	152 ± 2	413 ± 15	161 ± 6	311 ± 21
	No.	5	5	5	5	5	5	5	5	5
Ky.-Edmonson	Range	10	9-10	10-12	12-16	246-287	146-177	268-452	142-196	226-398
	Mean	10.0	9.7 ± 0.2	10.6 ± 0.2	14.6 ± 0.6	263 ± 6	155 ± 4	333 ± 29	164 ± 7	284 ± 22
	No.	8	8	8	7	7	7	7	7	8
Tennessee	Range	9-10	9-11	9-11	14-15	242-260	135-162	396-440	111-178	256-365
	Mean	9.3 ± 0.2	9.7 ± 0.3	9.6 ± 0.2	14.6 ± 0.2	250 ± 2	145 ± 4	418 ± 6	145 ± 11	317 ± 17
	No.	7	7	7	5	6	6	6	6	7
All	Range	9-11	9-11	9-12	11-16	218-309	135-181	268-457	111-198	226-407
	Mean	9.9 ± 0.1	9.8 ± 0.1	9.8 ± 0.1	14.2 ± 0.2	264 ± 3	157 ± 2	394 ± 5	160 ± 3	317 ± 7
	No.	31	31	31	28	41	42	42	41	35
cornutus All	Range	9-12	9-10	10-11	9-11	311-388	163-217	47-485	156-217	314-561
	Mean	10.9 ± 0.1	9.3 ± 0.1	10.1 ± 0.1	10.1 ± 0.2	341 ± 4	184 ± 2	250 ± 22	180 ± 3	468 ± 19
	No.	21	21	20	19	30	29	30	24	13

* Head proportions, anal-vent distance, and depth are given in thousandths of the standard length. Eye is given in ten thousandths of the standard length.

Individual variation in color is most evident in the amount of dark pigment on the caudal. The maximum amount is described above. In some *cornutus* the dark pigment takes the form of an oblong separated from the base of the caudal by a colorless area.

The dark lateral stripes are more conspicuous in younger fishes. In older specimens the dorsal coloration becomes darker, tending to obliterate the stripes.

Remarks.—Comparison with *C. agassizi* is made under that species. See also table 1.

Range.—Swamps of the southern Atlantic coastal plain.

GEORGIA. BRYAN CO.: Tributary of Black Creek near Blitchton (Raney, personal communication), Canoochee River near Ways; EMANUEL CO.: Little Ohoopee River, west of Swainsboro (Raney); JENKINS CO.: Ogeechee River near Millen; TELFAIR CO.: Little Ocmulgee River near McRae (Raney).

NORTH CAROLINA. BRUNSWICK CO.: Burnt Coat Swamp north of Wilmington, south of Wilmington (both localities from Raney); CRAVEN CO.: Lake Ellis; GATES CO.: Sunbury (Raney); HARTNETT-SAMPSON COS.: East of Dunn (Raney); MOORE CO.: Aberdeen (Raney); NEW HANOVER CO.: Wilmington; SAMPSON CO.: Clinton, Mingo Creek(Brimley and Mabee, 1925); SCOTLAND CO.: Tributary of Drowning Creek near Hoffman (Raney).

SOUTH CAROLINA. AIKEN CO.: Upper Three Runs Creek near Ellenton (Freeman, 1954); ALLENDALE CO.: Tributary of Jackson Branch near Sycamore, tributary of Salkahatchie River near Ulmers (both from Raney); BAMBERG CO.: Little Salkahatchie River between Denmark and Hilda (Raney), and north of Ehrhardt; BERKELEY CO.: Wassamassa Swamp; COLLETON CO.: Little Salkahatchie River near Bell's Crossroads; DARLINGTON CO.: Tributary of Pee Dee River at Society Hill (Raney); DILLON CO.: Pee Dee river; DORCHESTER CO.: Great Cypress Swamp, near Jedburg; JASPER CO.: Great Swamp, tributary of New River (Raney); MARION CO.: Little Pee Dee River; MARLBORO CO.: Near Bennettsville; RICHLAND CO.: Cabin Branch near Hopkins (Freeman, 1952).

VIRGINIA. NANSEMOND AND NORFOLK COS.: Dismal Swamp; SUSSEX CO.: 33 miles south of Reams on Rowanty Creek, a tributary of Nottoway River (Raney).

CHOLOGASTER AGASSIZI Putnam—Springfish

Fig. 2

Chologaster agassizi Putnam, 1872, p. 22—Lebanon, Tennessee.

Chologaster papilliferus Forbes, 1882, p. 2—spring, Union County, Illinois; 1881, p. 232 (description, no name).

Material examined.—Illinois 25 (1-CNHM; 21-IU; 3-UMMZ); Kentucky 12 (9-CNHM; 3-UMMZ); Tennessee 6 (5-UMMZ; 1-USNM).

Diagnosis.—Eye well developed; clearly visible under skin, with distinct pupil; scleral cartilages absent; postcleithrum present; body pigmented; pelvics absent; each half of caudal with a single row of sensory papillae.

Dorsal 9-11 (usually 10); anal 9-11 (usually 10); pectoral 9-12 (mostly 9-10); branched caudals 11-16 (mostly 14-15); vertebrae 33-35 (6 specimens).

Total length 29.9-80.5 mm; standard length 24.5-67.0 mm; head length 0.218-0.309; head width 0.135-0.181; depth 0.111-0.198; anal-vent 0.268-0.457.

Color (in alcohol) dusky, darker above than below; a conspicuous dark mid-dorsal stripe; usually a light mid-lateral streak; sometimes pigment of sides concentrated in oblique lines overlying myosepta, most often posteriorly. Fins generally pale; usually a row of chromatophores along edges of rays; caudal darkest, pectoral and anal lightest.

Remarks.—The fishes available to us come from four areas: southwestern Illinois; Livingston County in western Kentucky; Mammoth Cave and nearby Bowling Green, Kentucky (in tables 1 and 3 as "Ky.: Edmonson"); Dickson and Stewart counties and Nashville in north central Tennessee. The counts and proportions for each of these four groups are listed in table 3.

Statistically significant differences are found only in the following comparisons:

Illinois-Livingston, Kentucky (pectoral rays, head length).
Illinois-Edmonson, Kentucky (pectoral rays, anal-vent).
Illinois-Tennessee (dorsal rays, head length, head width, anal-vent depth).
Livingston, Kentucky-Edmonson, Kentucky (pectoral rays).
Edmonson, Kentucky-Tennessee (dorsal rays, pectoral rays, anal-vent).

According to Eigenmann (1909) the eye of *papilliferus* was much larger (5.5 in head) than in *agassizi* (10 in head). Our data (table 3) show some inter-population differences but only that between the Illinois and Edmonson, Kentucky samples approaches a statistically significant level. However, those differences can be ignored, for, as fig. 3 illustrates, the relative size of the eye decreases with increase in standard length.

Forbes' preliminary notes (1881) on *papilliferus* suggest that it differs in color from *agassizi*. Examination of our series does not bear Forbes out.

Yet, as noted above, the Illinois sample, representing *papilliferus*, does differ in certain respects from the Tennessee sample, which comes from near the type locality of *agassizi*. But compared to the differences between *cornutus* and *agassizi* (see table 3 and below), these differences involve fewer characters and are small in magnitude. Therefore, we cannot separate *papilliferus* and *agassizi* at the species level.

A case might be made for distinguishing them at the subspecies level. But if that is done, the Kentucky populations do not fall into either form without considerable strain on the subspecies concept. The Livingston sample agrees

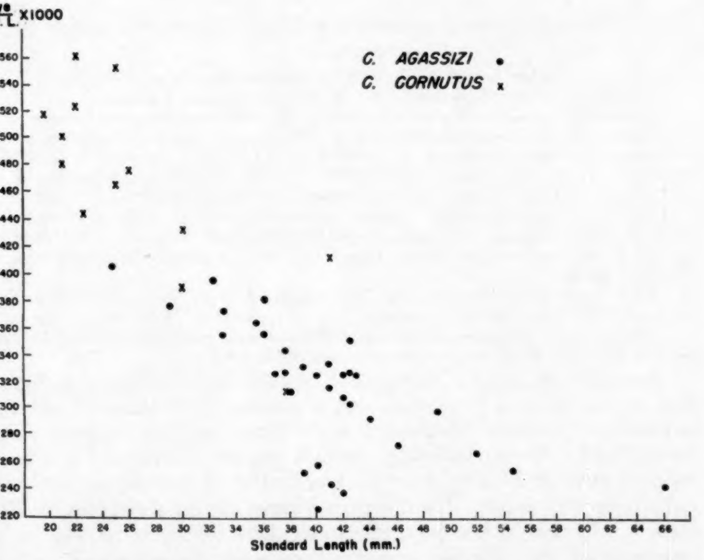

Fig. 3.—The relationship of relative eye size to standard length in *Chologaster*.

in all characters with the one from Tennessee but differs from the Illinois in head length and pectoral rays. The latter character, however, does not distinguish the Tennessee and Illinois samples.

The Edmonson sample differs from the other three in pectoral ray counts and from the Tennessee in dorsal ray counts also. Differences in anal-vent distance can probably be ignored because of age variation introduced by the forward migration of the vent during ontogeny.

Thus, instead of having two or three major subdivisions that are approximately equally distinct from one another, we have extremely local populations that are differentiated to varying degrees and in different characters. The situation is very similar to that found in *Typhlichthys subterraneus* and, as in that case, we are unable to recognize subspecies of *agassizi*.

Chologaster agassizi is quite distinct from *C. cornutus*. The two species differ in all the characters listed in table 3 except pectoral ray counts. In addition they are easily distinguished on the basis of color pattern. Only *cornutus* has a dark longitudinal streak in the lower half of the side; its pigmentation is generally more intense than that of *agassizi*.

Range.—Swamps, caves, and springs of the limestone region from southern Illinois to central Kentucky and north central Tennessee.

ILLINOIS. POPE CO.: Golconda; UNION CO.: South of Altridge, Larue, Wolf Lake.

KENTUCKY. EDMONSON CO.: Cedar Sink (Eigenmann, 1909), Mammoth Cave, (Buffalo Creek near Mammoth Cave); LIVINGSTON CO.: Cave Spring; WARREN CO.: Bowling Green.

TENNESSEE. DAVIDSON CO.: Nashville; DICKSON CO.: Jewel Cave; STEWART CO.: Dover; WILSON CO.: Lebanon (Putnam, 1872).

TYPHLICHTHYS SUBTERRANEUS Girard—Southern Cavefish

Fig. 4

Typhlichthys subterraneus Girard, 1859, p. 63—Bowling Green, Kentucky.

Typhlichthys osborni Eigenmann, 1905, p. 63—Horse Cave, Kentucky.

Typhlichthys wyandotte Eigenmann, 1905, p. 63—well near Corydon, Indiana.

Typhlichthys eigenmanni Hubbs, 1938, p. 265—Central Missouri (nomen nudum).

Material examined.—Alabama 10 (5-UMMZ; 5-USNM); Arkansas 1 (UMMZ); Indiana 2 (SU); Kentucky 32 (27-CNHM; 3-NPS; 2-UMMZ); Missouri 16 (12-UMMZ; 4-MU); Oklahoma 1 (KU); Tennessee 29 (20-CNHM; 9-UMMZ).

Diagnosis.—Eye rudimentary, hidden under skin; scleral cartilages absent; postcleithrum present; pigment cells normally not well-developed; body white, but developing pigment if fish kept in light; pelvics absent; each half of caudal usually with one row of sensory papillae.

Dorsal 7-10 (usually 8 or 9); anal 7-10 (usually 8 or 9); pectoral 9-12 (usually 10 or 11); branched caudals 10-15 (usually 12 or 13); vertebrae 28-29 (3 specimens).

Total length 21-77 mm; standard length 16.5-61.0 mm; head length 0.296-0.399; head width 0.167-0.236; depth 0.124-0.194; anal-vent 0.296-0.405.

Remarks.—Eigenmann distinguished *osborni* from *subterraneus* on the basis of differences in head width and in eye diameter. The head width was said to be 4.5 in the standard length of the former and 5 in the latter (Eigenmann, 1909). Clearly individual variation was not considered. In a freshly collected series of 20 fishes from the type locality of *osborni*, the head width varies from 4.67 to 5.5. The difference between the eye sizes given by Eigenmann is 0.05 mm. These populations may differ slightly in eye size, but the magnitude of the difference certainly approaches the magnitude of errors of measurement.

The type of *wyandotte* is lost and the type locality at Corydon, Indiana destroyed. However, since we have examined 2 specimens of *subterraneus* (SU-1310) from Corydon, we assume that the type of *wyandotte* was also *subterraneus*. The original description of *wyandotte* (Eigenmann, 1905) gives no characters that distinguish it from *subterraneus*.

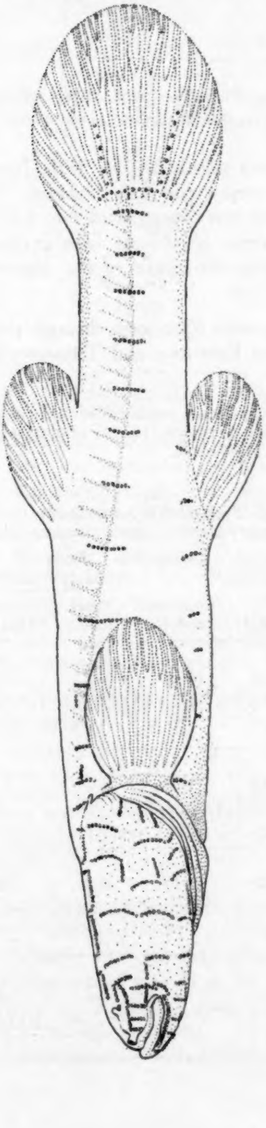

Fig. 4.—*Typhlichthys subterraneus* (x 3).

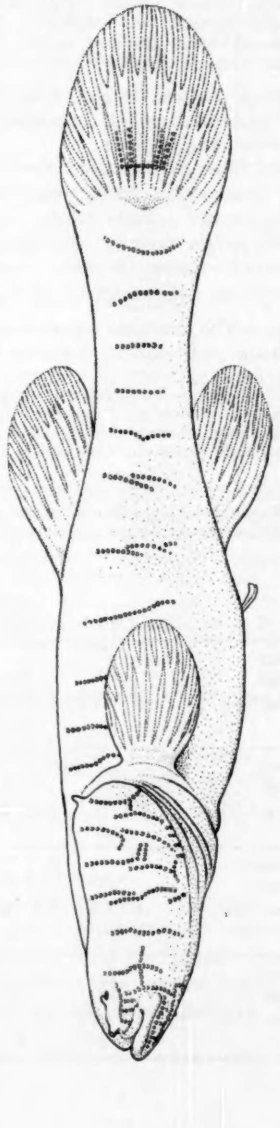

Fig. 5.—*Amblyopsis spelaea* (x 4).

The *Typhlichthys* seen show much less inter-populational differences than species of either *Amblyopsis* or *Chologaster* (see table 1). Of the characters tabulated (table 4), statistically significant differences occur only in the following comparisons:

Kentucky-Tennessee (pectoral rays, head length).
Kentucky-Alabama (pectoral rays, head length).
Kentucky-Missouri (head length).
Tennessee-Missouri (branched caudals, head width).
Missouri-Alabama (head width).

No distinct pattern of geographic variation emerges from these comparisons. On the basis of our specimens it is impossible to define even subspecies in this wide ranging form.

Several fishes from Coffee County, Tennessee were kept alive in the laboratory for three months during which time they were exposed to daylight. They gradually assumed a dusky color. The pigment was concentrated into a broad mid-lateral streak, tapering caudally, and a series of oblique lines overlying the myosepta. Except for a few short streaks on the caudal of one specimen, chromatophores did not appear on the fins.

Range.—The limestone region from northeastern Oklahoma through southern Missouri and northern Arkansas to central Kentucky and Tennessee and northern Alabama.

ALABAMA. JACKSON CO.: Salt River Cave (Barr, personal communication); LAUDERDALE CO.: Hines, Florence; LAWRENCE CO.: Moulton (Putnam, 1872); MADISON CO.: Shelta Cave near Huntsville, Cave Spring Cave near New Hope.

TABLE 4.—Comparison of several samples of *Typhlichthys subterraneus*

					Rows of caudal papillae	
Sample	Dorsal	Anal	Pectoral	Branched caudals	Dorsal half	Ventral half
Missouri						
Range	8-9	8-9	10-12	10-14	1-2	0-1
Mean ± SE	8.3 ± 0.1	8.6 ± 0.2	10.9 ± 0.2	11.4 ± 0.4	1.2 ± 0.1	0.9 ± 0.1
No.	13	11	13	10	13	13
Kentucky						
Range	7-9	7-10	10-12	11-13	1-2	1
Mean ± SE	8.3 ± 0.1	8.3 ± 0.1	11.0 ± 0.1	12.2 ± 0.2	1.1 ± 0.1	1.0
No.	32	32	32	12	31	31
Tennessee						
Range	7-10	8-9	9-11	11-15	0-2	0-2
Mean ± SE	8.5 ± 0.1	8.5 ± 0.1	10.5 ± 0.1	12.8 ± 0.3	1.0 ± 0.1	1.0 ± 0.1
No.	24	24	26	11	27	27
Alabama						
Range	8-9	7-9	9-12	——	0-2	1-2
Mean ± SE	8.5 ± 0.2	8.4 ± 0.2	10.3 ± 0.3		0.9 ± 0.1	1.1 ± 0.1
No.	10	9	9		9	9

TABLE 4.—(*continued*)

Sample	Head length*	Head width*	Anal-vent*	Depth*
Missouri				
Range	330-384	185-236	296-374	139-190
Mean ± SE	348±4	207±4	347±6	163±3
No.	13	12	13	13
Kentucky				
Range	296-343	169-213	331-405	127-189
Mean ± SE	319±2	200±2	373±3	159±3
No.	29	29	29	29
Tennessee				
Range	309-376	182-220	333-405	127-194
Mean ± SE	339±3	196±3	373±5	163±6
No.	20	16	20	15
Alabama				
Range	309-399	167-209	360-390	124-170
Mean ± SE	343±7	191±4	375±4	157±6
No.	10	10	9	8

* These proportions are given in terms of thousandths of the standard length.

ARKANSAS. RANDOLPH CO.: Well.

INDIANA. HARRISON CO.: Corydon.

KENTUCKY. BARREN CO.: Cave City (Cox, 1905), Mitchell's Cave near Glasgow; EDMONSON CO.: Mammoth Cave, Stillhouse Hollow Cave; HART CO.: Horse Cave; WARREN CO.: Bowling Green (Girard, 1859), Rich Pond (Orr, 1934).

MISSOURI. CAMDEN CO.: River Cave; GREEN CO.: Springfield; LACLEDE CO.: Bennett Spring; OREGON CO.: Roaring Spring; SHANNON CO.: Welch's Cave.

OKLAHOMA. OTTAWA CO.: Cave Spring near Peoria.

TENNESSEE. COFFEE CO.: Blowing Spring Cave, Crystal Cave near Monteagle, Sink Hole Cave near Wonder Cave; HARDIN CO.: Cave near Dry Creek; RUTHERFORD CO.: Murfreesboro; WILSON CO.: Lebanon.

The following Tennessee localities were supplied by Barr (personal communication).

GRUNDY CO.: Big mouth-Big room cave system, Payne's Cove; HICKMAN CO.: Cave Branch Cave, near Pleasantville; MONTGOMERY CO.: Dunbar Cave near Clarksville; OVERTON CO.: City Water Supply Cave No. 2 at Livingston; PERRY CO.: Blowing Caves, near Pleasantville; PUTNAM CO.: Blindfish Cave in Long Valley; WARREN CO.: Panter's Cave, near Irving College.

AMBLYOPSIS DeKay

Amblyopsis DeKay, 1842, p. 187—type *Amblyopsis spelaeus* DeKay.
Troglichthys Eigenmann, 1899, p. 282—type *Typhlichthys rosae* Eigenmann.

One of the principal differences between *Troglichthys* and *Amblyopsis* is the presence of pelvics in the latter. However, the extreme variability of the pelvics in *A. spelaea* (see below) suggests that little significance can be attached to this character.

Eigenmann (1899, 1909) and Cox (1905) also emphasized the differences

in the eyes of *Amblyopsis* and *Troglichthys*. Eigenmann (1899) noted the following differences: cones well developed in *Amblyopsis* (A), absent in *Troglichthys* (T); pigment epithelium well developed (A), pigment on distal face of eye only (T); ganglionic cells forming a mass through center of eye (A), ganglionic cells reduced to a thin layer (T); maximum diameter of eye 200μ (A), maximum diameter 85μ (T). In every respect the eye of *rosae* is more degenerate than that of *spelaea*.

Thus in both structures *rosae* is simply a more specialized form of *Amblyopsis*. Other similarities of *spelaea* and *rosae* that distinguish them from *Typhlichthys* and *Chologaster* (compare diagnoses and fig. 9) also argue against the recognition of *Troglichthys*.

AMBLYOPSIS SPELAEA DeKay—Northern Cavefish

Fig. 5

Amblyopsis spelaeus DeKay, 1842, p. 187—Mammoth Cave, Kentucky.

Material examined.—Indiana 37 (6-Carnegie Museum; 11-CNHM; 5-IU; 15-UMMZ); Kentucky 7 (6-NPS; 1-UMMZ).

Diagnosis.—Eye rudimentary, hidden under skin; scleral cartilages present; no postcleithrum; pigment cells not functional; body white, without pattern; pelvics usually present; each half of caudal with at least two rows of sensory papillae.

Dorsal 9-11 (most often 10); anal 8-11 (usually 9 or 10); pectoral 9-11 (usually 10); pelvics 0-6 (most often 4); branched caudals 11-13 (usually 12 or 13); vertebrae 29-30 (7 specimens).

Total length 19-105 mm, standard length 15.0-84.0 mm; head length 0.319-0.399; head width 0.193-0.267; depth 0.150-0.236; anal-vent 0.060-0.377.

Remarks.—This species differs from its congener, *rosae*, in the number of dorsal rays, the number of anal rays, the number of branched caudal rays, the presence of the pelvic fin, the relative width of the head, and the relative distance between the vent and anal fin (see table 5). Although in all amblyopsids the last proportion changes radically as the vent migrates forward during growth, the difference between *spelaea* and *rosae* is independent of size. All

TABLE 5.—Comparison of the species of *Amblyopsis*

	spelaea			*rosae*		
	Range	Mean	No.	Range	Mean	No.
Dorsal	9-11	10.0±0.1	43	7-8	7.4±0.1	19
Anal	8-11	9.6±0.1	43	8-9	8.3±0.1	18
Pectoral	9-11	10.1±0.1	42	10-12	10.3±0.1	18
Ventral fin	0-6	3.8±0.2	44	0	—	20
Branched caudals	11-13	12.4±0.2	16	9-11	10.0±0.3	8
Rows of caudal papillae:						
Dorsal half	2-3	2.2±0.1	35	2-3	2.7±0.1	15
Ventral half	2-3	2.3±0.1	35	2	2.0	15
Head length*	319-399	351±9	34	320-406	361±5	18
Head width*	193-267	223±4	28	214-263	237±3	18
Anal-vent*	60-377	327±9	32	348-420	376±4	18
Depth*	150-236	205±5	22	175-224	203±3	18

* These characters are given in terms of thousandths of a standard length.

specimens of *spelaea*, excluding the two smallest, are larger than the largest *rosae* seen; yet the vent is closer to the anal in *spelaea*.

Range.—The limestone region of Indiana from Bedford south to Corydon and the area around Mammoth Cave, Kentucky.

INDIANA. CRAWFORD CO.: Caves near Corydon (Seibert's Well, Sheep Cave); LAWRENCE CO.: Caves in and near Spring Mill State Park (Bronson's Cave, Donaldson's Cave, Hamer's Cave [Packard, 1886], Shawnee Cave [Eigenmann, 1909], Twin Caves); ORANGE CO.: Lost River, Elrod's Cave near Orleans (Packard, 1886); WASHINGTON CO.: Clifty Caves near Campbellsburg (Packard, 1886).

KENTUCKY. EDMONSON CO.: Cave in Cedar Sink, and Mammoth Cave.

AMBLYOPSIS ROSAE (Eigenmann)—Ozark Cavefish

Fig. 6

Typhlichthys rosae Eigenmann, 1898, p. 231—Sarcoxie, Missouri.

Material examined.—Missouri 23 (3-CNHM; 1-MU; 18-UMMZ; 1-USNM).

Diagnosis.—Eye rudimentary, hidden under skin; scleral cartilages present; no postcleithrum; pigment cells not functional; body white, without pattern; pelvics absent; each half of caudal with at least two rows of sensory papillae.

Dorsal 7-8 (usually 7); anal 8-9 (usually 8); pectoral 10-12 (most often 10); branched caudals 9-11; vertebrae 28 (1 specimen).

Total length 36-54 mm; standard length 24.0-42.5 mm; head length 0.320-0.406; head width 0.214-0.263; depth 0.175-0.224; anal-vent 0.348-0.420.

Remarks.—Comparison with *spelaea* has been made above.

Range.—The southwestern corner of Missouri.

MISSOURI. BARRY CO.: Cassville; GREEN CO.: Moore's Cave near Springfield; JASPER CO.: Caves in or near Sarcoxie (Day's Cave, Downer's Cave, Wilson's Cave); NEWTON CO.: Neosho; STONE CO.: Cave Spring near Elsey.

MORPHOLOGICAL NOTES

Starks (1904), amplified by Regan (1911), described the skeleton of *Amblyopsis*. The following comments, based on all genera, are intended only as supplements to previous descriptions and to form a basis for a discussion of the phylogeny of the family.

Cranial skeleton.—The premaxilla in all amblyopsids is a horizontal toothed bone bearing a short triangular dorsal process medially and reaching the corners of the lips. The maxilla is completely excluded from the gape.

Three well-developed suborbital bones are present in *Typhlichthys, Chologaster,* and *Amblyopsis spelaea,* but in a small specimen (34.5 mm) of *A. rosae* only two thin suborbitals could be distinguished.

Axial skeleton.—The vertebral column in all amblyopsids is attached to the skull by the basioccipital and the exoccipitals. The neural spines of the anterior vertebrae are slender and pointed. The penultimate vertebra is straight in *Chologaster cornutus* and *Amblyopsis rosae,* bent upwards slightly in *agassizi* and *Typhlichthys subterraneus,* and strongly bent upwards in *A. spelaea.*

The first two vertebrae bear sessile ribs, attached to the centrum just posterior to the base of the neural arch. All subsequent ribs are attached to parapophyses. The epipleurals are inserted on the ribs, lateral to the para-

pophyses, and extend between the dorsal and ventral muscle masses to a point just beneath the skin near the lateral nerve (fig. 7A).

Appendicular skeleton.—Baudelot's ligament connects the pectoral girdle (supracleithrum) with a strong triangular parapophysis on the anterior ventral face of the first vertebra (fig. 7C).

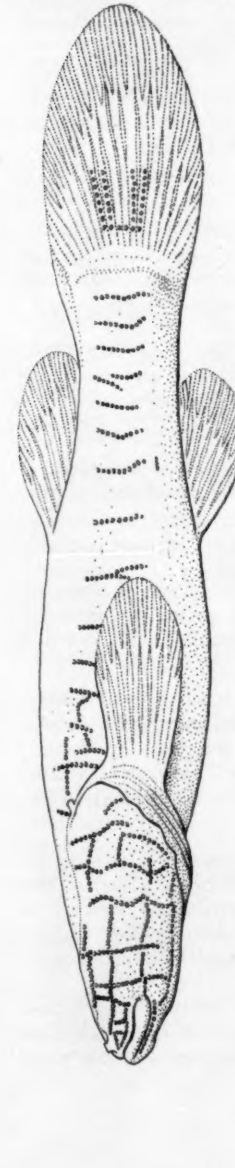

Fig. 6.—*Amblyopsis rosae* (x 8).

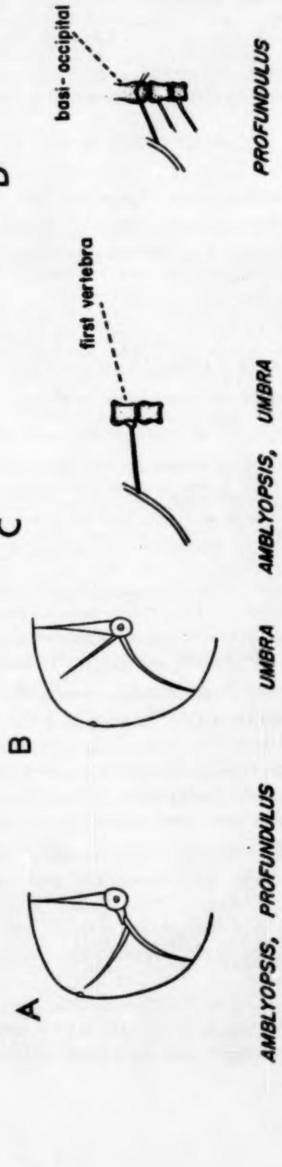

Fig. 7.—Attachment and position of epipleurals (A and B) and attachment of pectoral girdle (C and D) in *Amblyopsis, Profundulus,* and *Umbra.*

The postcleithrum in *Chologaster* and *Typhlichthys* is a thin splint of bone on the inner face of the pectoral girdle, running parallel to the plane of the cleithrum from the dorsal level of the cleithrum to the ventral edge of the radials. In *Chologaster* the postcleithrum is uniform in width throughout its length and is sinuous in the sagittal plane. The bone is straight in *Typhlichthys* and wider at the ventral end.

Amblyopsis typically lacks a postcleithrum. Only two *spelaea* out of a total of 44 *spelaea* and 23 *rosae* had a vestige consisting of a very small, flat crescent located near the upper border of the cleithrum.

Scales (fig. 8) are thin, imbedded, and imbricate in all genera. The focus is slightly closer to the posterior margin. The circulae are broken posteriorly by secondary radii and anteriorly by primary and secondary radii.

RELATIONSHIPS AND PHYLOGENY

The Amblyopsidae were placed by Starks (1904) as a superfamily in the Order Haplomi, which he considered a heterogeneous group including the superfamilies Esocoidea, Poeciloidea, and Amblyopsoidea. Starks came to no conclusions as to the relations of the amblyopsids to these other groups except to put them in one order.

Regan (1911) separated the amblyopsids and cyprinodonts from the true haplomous fishes. According to Regan the first two groups, which formed his new order Microcyprini, differed from the Haplomi in being physoclistic and in having the mouth bordered by the premaxillaries only, the mesethmoid unpaired, and the ribs inserted on strong transverse processes. The Microcyprini also differ from the haplomous *Umbra* in the position and attachment of the epipleurals (fig. 7A and B). Regan distinguished the Suborder Amblyopsoidea on the basis of: mouth not protractile, gill membranes fused to isthmus, vent jugular, palatines distinct from pterygoids, and the metapterygoid present. In addition Regan stated that the Amblyopsoidea had no postcleithrum. However, as we have just pointed out, this bone is present in *Typhlichthys* and *Chologaster*.

Hubbs (1924) also includes the Amblyopsidae in the Order Cyprinodontes (=Microcyprini Regan), noting that the group also differs from the Haplomi in having the base of the pectoral rather high and vertical.

Our observations in general agree with those of Regan and Hubbs and we concur in Regan's taxonomic arrangement. We have found the following additional differences between the Amblyopsoidea and the Poecilioidea:

AMBLYOPSOIDEA	POECILIOIDEA
Premaxillary straight	Premaxillary curved and bent
Postcleithrum a thin splint or absent	Postcleithrum ovate at proximal end
Scales small, embedded	Scales large, not embedded
Penultimate vertebra bent upwards	Penultimate vertebra straight
Shoulder girdle attached to first vertebra by Baudelot's ligament (fig. 7C)	Shoulder girdle attached to basioccipital by ligament (fig. 7D)
Suborbital bones present	Suborbital bones absent
Sensory papillae on body and caudal	No sensory papillae on body and caudal
Anterior neural spines simple, pointed	Anterior neural spines (2-5) broad and leaflike

Certain of the differences between the poecilioids and the amblyopsids appear to reflect the divergent evolutionary trends of the two groups. For

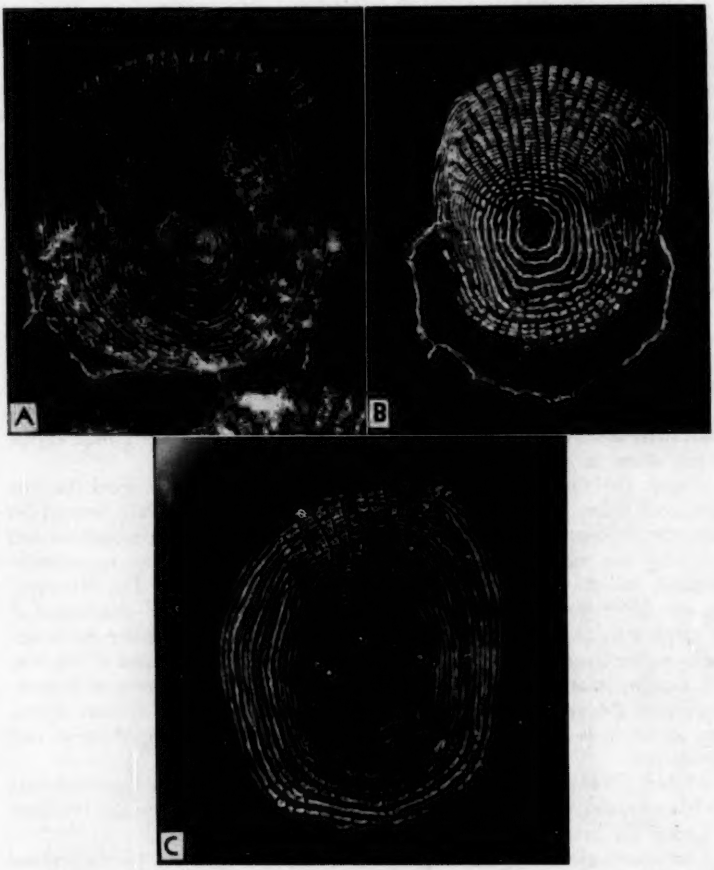

Fig. 8.—Scales of amblyopsids. Anterior edges towards top. A. *Typhlichthys subterraneus;* B. *Amblyopsis rosae;* C. *Amblyopsis spelaea.*

example, the sensory papillae scattered over the body and caudal in amblyopsids obviously constitute an adaptation to a life in which the significance of light is greatly reduced. Though *Chologaster agassizi* is not restricted to caves and *C. cornutus* is never found in caves, their habits keep them in situations with limited visibility. They tend to hide under bottom debris such as leaves and stones in swampy streams or in pools at the mouths of springs. The imbedding of the scales is probably related to the papillae since superficial scales would not leave space for this development. In other, non-related swamp fishes such as *Umbra,* which also is well supplied with similar papillae, these sense organs are distributed in scale-less parts of the body or where the skin is thick over

the scales. In *Umbra* the papillae occur between the rays of the caudal, on the top of the head over the canals, and over the bases of the scales on the anterior part of the body. In *Aphredoderus* the papillae are particularly abundant along the mandibular rami and on the top of the head.

Degeneration of the eyes may be viewed as a consequence of the relaxation or elimination of the selective pressure normally operating on these organs. Therefore the reduction of the eyes, the imbedding of the scales, and the development of the papillae are all responses to the same factor in the environment, namely, the reduction or absence of light.

While it has been shown that the eggs are carried in the gill cavity only in *Amblyopsis,* the jugular position of the genital papilla and the attachment of the gill membranes to the isthmus in all amblyopsids may be associated with this type of reproductive behavior.

The distribution of scleral cartilages (Eigenmann, 1899, 1909) and pectoral girdle elements in the three genera of amblyopsids sheds light on the phylogeny within the family. At least two independent lines of optic degeneration must be assumed. The relatively well-developed eyes of *Chologaster* forces us to visualize the ancestral amblyopsid as an eyed form. The absence of scleral cartilages in *Chologaster* and their presence in *Amblyopsis* prevents deriving the latter from the *Chologaster* stock. *Typhlichthys,* which also lacks scleral cartilages, could be an off-shoot from a *Chologaster*-like population. It cannot, however, be derived from an *Amblyopsis*-like stock because the latter lacks a postcleithrum, which is found in both the other genera. The scleral cartilages prevent our considering *Amblyopsis* a derivative of a *Typhlichthys* stock.

Therefore, only two conceivable phylogenies remain. According to one of these, each genus represents a separate line from the ancestral amblyopsid. The second possibility has *Amblyopsis* as one off-shoot from the basal stock and *Chologaster* and *Typhlichthys* representing another, with the last being a derivative of a *Chologaster* stock (fig. 9).

DISTRIBUTION AND DISPERSAL

The present range (fig. 10) of all except one species of the family Amblyopsidae lies between the glaciated area (southern limit indicated by dashed line) and the Cretaceous shoreline of the Mississippi embayment (dotted line), occupying only 6 degrees of latitude between 32° and 39° N. The climate of this region is such that water is not frozen at the surface for a very long period in winter so there is more or less continuous inflow of food into the caves although the amount may be greatly reduced in winter and during periods of drought. The range does not include regions of frequent, prolonged drought. The temperature of the cave and spring waters inhabited by amblyopsids ranges between 50° and 60°F. Temperature of waters in swamps and streams inhabited by rice fish certainly fluctuate more than in caves and springs but the extremes are not exactly known. Very likely the temperature in the mud of swamps and streams in which *C. cornutus* lives ranges from 39° to 80°F.

Chologaster cornutus is limited to the relatively sluggish, sheltered waters of streams and to cypress swamps within its range from approximately 50 miles

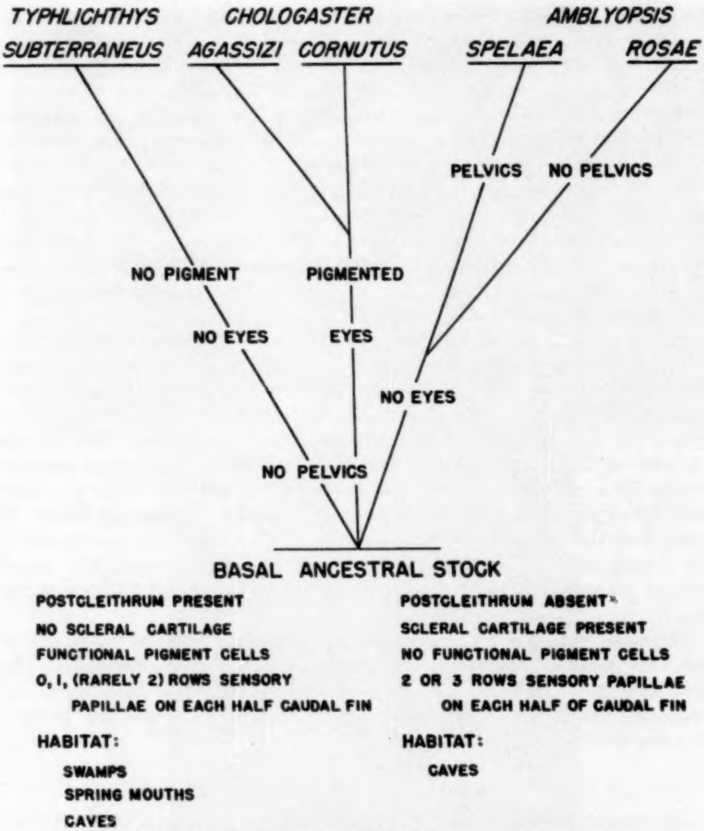

Fig. 9.—Suggested phylogeny within the family Amblyopsidae.

inland to the coastal swamps that are *not brackish*. It has never been taken above the fall line. There is no apparent reason why this species should not range into the Okeefenokee or farther west into Alabama; the habitats are similar and associated forms such as *Umbra, Gambusia, Aphredoderus* and *Elassoma* do range far to the west just seaward of the Mississippi embayment shoreline even to beyond the Mississippi River. The only explanation that can be offered is that its range formerly did extend at least as far as the Mississippi River and that during some period of drought during late or even post glacial times its habitat dried up and it has not been able to migrate as rapidly as the more active and better adapted species of the widespread genera mentioned above.

Chologaster agassizi is associated with the Mississippian limestone regions of Kentucky, Tennessee, and Illinois. They are found more often in caves

and mouths of springs but occasionally have been collected in swamps and creeks adjacent to limestone areas. We are of the opinion that the ranges of the two populations of *agassizi* will eventually be found to be continuous. Since these fishes do enter and live deep in caves it is possible for them to pass under surface watershed divides. And since they can live in streams, they could distribute themselves all along a river such as the Cumberland. Western Kentucky and southern Illinois have not been sufficiently explored.

Typhlichthys subterraneus is apparently limited to underground waters, so far reported only from caves, spring mouths and wells, and is completely blind and normally without pigment. It has long been known from Mammoth Cave and Horse Cave, Kentucky, though the population in the latter cave was called *T. osborni*. *T. subterraneus* is also known from the Cumberland and Tennessee drainage systems. It occupies the central portion of these river systems, the Nashville basin and one large valley area, and another basin in southern Tennessee and north Alabama, but has not been discovered in either the lower entrenched portions of the Cumberland and the Tennessee or the region where these rivers enter the Cumberland Plateau.

The same species is found in south central Missouri and northeastern Oklahoma. Although it has also been reliably reported from two localities in St. Francois County in southeastern Missouri, no specimens from there are available for study. At some time distribution of this species was probably continuous, or may still be, to the mouths of the Cumberland and Tennessee

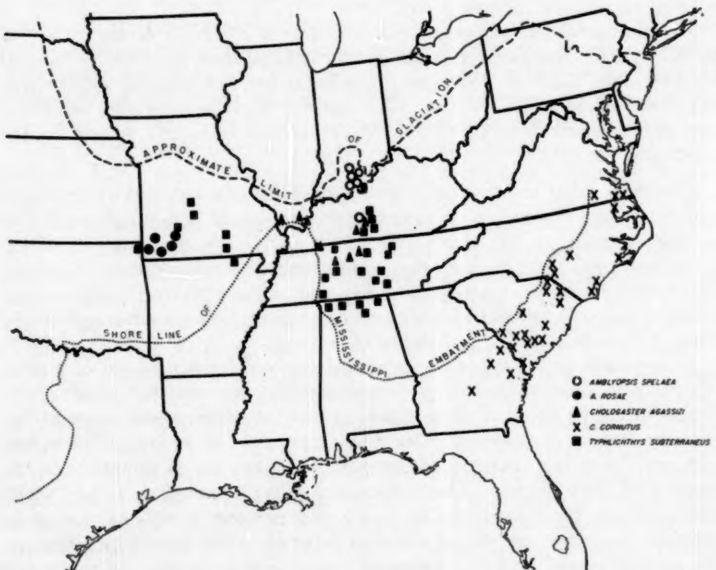

Fig. 10.—Geographic distribution of amblyopsids.

Rivers, across southern Illinois (Ozark Ridge) and by way of St. Genevieve limestone into Missouri.

Amblyopsis rosae is limited in its range to the Springfield Plateau of southwestern Missouri. It is found only in wells, springs and caves. *A. rosae* is a very distinct species and is certainly well isolated geographically from its nearest relative, *A. spelaea,* at present.

Amblyopsis spelaea is abundant but limited in its range to caves in the unglaciated portions of southern Indiana and in the Mammoth Cave area. Although the species was originally described from specimens collected in Mammoth, the only recent record of it from there is of a 3.5 inch specimen caught in Echo River along with six *T. subterraneus* and reported to us by Mr. R. C. Burns, Park Naturalist (letter dated 2 Aug. 1956). Only one specimen has been collected from adjacent territory (Cedar Sink Cave in 1939).

The relative abundance of *spelaea* in southern Indiana and its scarcity in the Mammoth Cave area, which is a good cavefish habitat (as witness the many *T. subterraneus* collected there), form a striking contrast. A possible explanation of this peculiar distribution may lie in a restriction of habitat of the sort that often takes place when the ranges of two related species overlap (for example see Lack, 1949). In southern Indiana *spelaea* is found in both large and small underground streams. In Mammoth Cave it may be restricted by virtue of competition with *subterraneus* to the large, deep streams such as Echo River. If *spelaea* is limited in this way, its scarcity in the Mammoth area may be apparent rather than real, for the large underground rivers are much more difficult collecting sites.

An alternative explanation is that continuous collecting of the fishes for sale over the last hundred years has greatly reduced their numbers. However, this alternative assumes that human predation has not affected *subterraneus* and, therefore, must be rejected. Our experience in the cave area of central Kentucky indicates that any blind, white cavefish is eagerly sought by the commercial interests.

Dispersal.—The dispersal of white, blind fishes through surface drainages presents ecological problems of such magnitude as to be highly unlikely. The fact that populations of *Amblyopsis* and *Typhlichthys* exist only in subterranean systems is good evidence that surface waters do not constitute a suitable environment for them. Consequently dispersal of these genera through surface drainages can only be equated with waif or accidental dispersal through a very strong filter zone with low probability of success.

Perhaps on rare occasions an individual fish will be washed out of a cave. The rarity of these individuals is demonstrated by the total failure of ichthyologists to collect either of these genera outside of underground systems. Because the surface environment is so disadvantageous, an ability to locate subterranean waters is a necessity for these waifs if they are to contribute to the dispersal of their species. The numerous papillae scattered over their whole bodies indicate great sensitivity to tactile and pressure stimuli so that slight variations in current are almost certainly detected. This sensitivity might enable an amblyopsid waif to locate underwater spring mouths. In the region inhabited by cavernicolous amblyopsids, springs are numerous enough to provide many opportunities for re-entry into the ground water system.

Typhlichthys subterraneus is found in Shannon County, Missouri, in an area drained by one of the tributaries (Jack's Fork) of the White River (a tributary of the Mississippi) and 75 miles across the Ozark Plateau in Laclede County, Missouri, in an area drained by the Niangua River, a tributary of the Missouri River (fig. 10). To explain the occurrence of *subterraneus* in these two places, separated by more than 1000 river miles, by means of dispersal in surface waters is to rely upon a large series of highly improbable events. Each of these events—the successful waifing of a *Typhlichthys* from one spring to another in surface waters—has a low probability. For the species to move, say, 500 miles by this method requires that the low probability of each step be multiplied by the low probabilities of all the succeeding steps. The end result is an infinitesimally small probability for the whole process.

The most likely explanation for the dispersal of the cave-limited amblyopsids depends on movement through subterranean channels below the water table. It is obvious from the existence of these cavernicolous populations that the conditions for the survival of the amblyopsids in ground water are favorable. Therefore, ground water solution channels do not constitute a barrier or filter zone of anything like the same rigor as surface drainages.

The strictly cave-limited amblyopsids have been found only in the physiographic provinces of the central United States designated by Fenneman (1938) as the Interior Low Plateau and the Ozark Plateaus (see map). These provinces have in common a thick series of almost horizontal Mississippian limestone formations perforated by numerous ground water solution channels and noted for their caves, springs, and sink holes. The limestone formations pass underneath the present surface drainage, including the Tennessee, Cumberland, and Mississippi rivers, and ground water has been found circulating through solution channels that are 100 feet below the present bed of the Tennessee River (Moneymaker and Rhoades, 1945). Under these circumstances even the major surface rivers do not interrupt the ground water systems.

On three occasions an amblyopsid was seen but not captured, by one or both of us, in a spring well near the crest of a divide in southwestern Missouri (fig. 11). The well (southeast corner of Section 24, T26N, R27W, about 2 miles southwest of Verona, Lawrence County) is at an elevation of 1360 feet. The crest of the nearest divide, which lies about one mile from this point, is at an elevation of 1450 feet; maximum elevation in the entire general area is 1500 feet. The stream formed by the spring well is a head water of the Spring River, a tributary of the Neosho River, in turn a tributary of the Arkansas. Two miles to the south, at elevations between 1450 and 1500 feet, lies a major divide between the Arkansas and White River drainages. Thus this amblyopsid (whether one or several individuals) was living almost at the top of the Springfield Plateau and probably could move from one major drainage to the other. These observations provide good presumptive evidence that, in these regions of horizontal limestones, surface divides do not form barriers to the dispersal of amblyopsids. It is noteworthy that *Amblyopsis* and *Typhlichthys* have not been found in the areas of deformed rock strata immediately to the south of the Ozark Plateaus in the Ouachita Province (of Fenneman) or to the east of the Interior Low Plateau in the Appalachian Plateau.

The dispersal of the cavernicolous amblyopsids may be visualized as follows. Some time during the Tertiary these fishes (or their ancestral form or forms) moved into the ground water of the interior limestone plateaus. Since the bulk of geological evidence indicates that the dissolving of these limestones takes place below the level of the water table (Bretz, 1942), the first cave amblyopsid probably moved into an already complex network of channels offering avenues of dispersal through much of these physiographic provinces. Aimless movement gradually carried the amblyopsids into all the areas they now occupy. This process must not be viewed as continual and without interruption because it cannot be assumed that all of the ground water networks of this limestone region have been continually interconnected. Fluctuations of the water table may effectuate or interrupt such connections.

Apparently more than one wave of dispersal took place in these ground water systems. The present distribution of *Amblyopsis* is typical of relicts, with the two populations separated and along borders of the family range. As shown elsewhere (p. 249), *Typhlichthys* and *Amblyopsis* represent distinct branches of the family so that the two *Amblyopsis* populations cannot be viewed as parallel derivatives of *Typhlichthys* that developed approximately in the areas they now occupy.

The present ranges of *Amblyopsis* could conceivably have been reached by dispersal from the north followed by elimination of intervening northern populations during the Pleistocene glaciations. But, since there is no evidence that amblyopsids ever occurred north of the interior plateaus and as good habitats for the cave genera are rather scarce and widely separated north of these

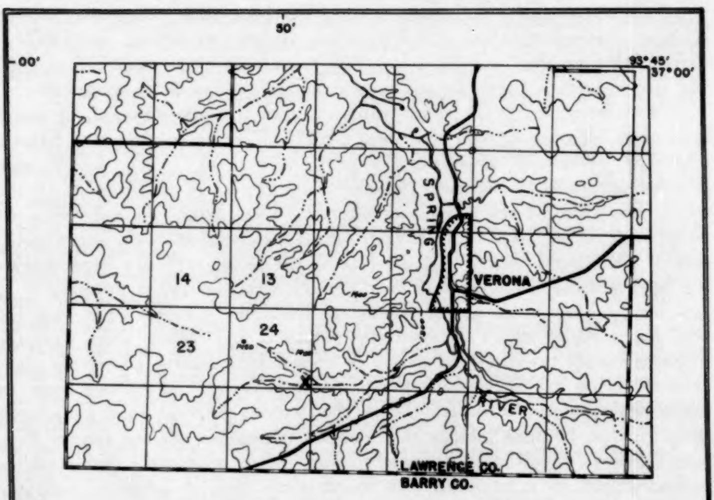

Fig. 11.—Topography at location of sight record of amblyopsid in Lawrence County, Missouri. Cross marks location of well in which fish was seen.

plateaus, it is much safer to assume that the northern boundary of the family range was never much if at all north of what it is today.

Consequently, the most reasonable explanation of the current distribution of the cave amblyopsids seems to us to be that *Amblyopsis* spread through the limestone plateaus and was then split and forced into two isolated pockets by the competitively more successful *Typhlichthys*. Once isolated the two *Amblyopsis* populations diverged genetically and acquired their contemporary distinctions, while the *Typhlichthys* population has remained more or less in continuity and thus has not been able to fragment into distinguishable forms.

Chologaster agassizi is less restricted to subterranean waters than *Amblyopsis* or *Typhlichthys*. Although most specimens have come from cave mouths or springs, at least four individuals (CNHM 43978) have been collected in a surface stream. *Chologaster cornutus* has never been reported from caves or springs, but is found in surface streams and swamps. It is likely that its ability to survive in surface waters has enabled *Chologaster* to live outside the regions of almost horizontal limestones. It is clear that at least *C. cornutus* can utilize surface waters for dispersal. Probably the ancestral stock of *cornutus* migrated from the Interior Low Plateau south around the Appalachians in the ring of swamps fringing the old Mississippi embayment.

SUMMARY

The five recognized species of amblyopsids are grouped into three genera on the basis of the pectoral girdle, scleral cartilages, and presence of eyes in adults.

The epipleurals of amblyopsids are attached to the ribs lateral to the rib attachments, an arrangement held in common with the cyprinodonts and distinguishing both from the Haplomi. Differences between these two groups are sufficient to recognize each as a distinct suborder of the Microcyprini.

The strong development of sensory papillae, the imbedding of the scales, the jugular vent, and the fusion of the gill membranes to the isthmus represent specializations of the amblyopsids from the basal microcyprinoid stock.

The amblyopsids, except for one species, are distributed in the limestone region of the central United States between the Appalachian Mountains and the Great Plains, south of the limit of glaciation and north of the Cretaceous Mississippi embayment. *Chologaster cornutus* is found in the Atlantic Coastal Plain from Virginia to central Georgia.

The cavernicolous *Amblyopsis* and *Typhlichthys* apparently disperse through subterranean channels below the water table. *Chologaster*, at least the species *cornutus*, is probably able to migrate through sluggish surface streams.

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